

THE NEW SCIENTIST

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CONTENTS

NOTES AND COMMENTS 1681

1960 Science survey 1685

Professor H. M. BARLOW
M. JAMES LIGHTHILL, FRS
Sir JOHN COCKCROFT, OM, FRS
Sir HARRIE MASSEY, FRS
Sir HENRY DALE, OM, FRS
Dr. M. H. F. WILKINS, FRS
Professor S. K. RUNCORN

Jules Verne's *Lunik* 1690

NIGEL CALDER

How modern chemistry conserves antiquities 1693

A. E. WERNER

AMERICAN NEWSLETTER 1697

Dr. A. E. Russell: A PROFILE 1698

SCIENCE IN BRITISH INDUSTRY 1700

Rigid foam houses: Electronic signal control:
Computer ousts the template: Measurement of
tube eccentricity.

SCIENCE IN OVERSEAS INDUSTRY 1702

Detecting one part in a hundred billion: New
route to urea: Automatic thickness control:
Containing leaks in a water-cooled reactor:
Flying saw for moving pipes: Petrol in drink-
ing water: Tough surfaces for metals: Smooth
extrusion: Gas boosts furnace output: Opti-
mum forging temperature: Thermal fatigue:
Ridding sheep of liver fluke: Mechanizing
the sugar-cane harvest.

When insulators conduct 1704

Dr. G. T. WRIGHT

Pyroceram 1708

Dr. CHARLES H. GREENE

IT SEEMS TO ME 1711

TRENDS AND DISCOVERIES 1712

Easy way to gauge X-ray doses: Are brains
one-sided?: Pulsing artery may start gastric
ulcers: Pulsing reactors for biomedical re-
search: Two-way proteins in pregnant
monkeys: How many more new elements?:
Queen ants retard larvae: New substance sifts
big molecules: How to spot a chicken virus.

BOOKS 1714

Reviews by Sir Cyril Burt, Dr. Peter Sykes,
Elizabeth Percival and Dr. D. W. Snow.

LETTERS 1716

UNESCO takes to the seas: Roman nails:
Hydrofoil boats: Photons as eels: The machine
tools controversy.

CONTRIBUTORS 1718

CLASSIFIED ADVERTISEMENTS 1719

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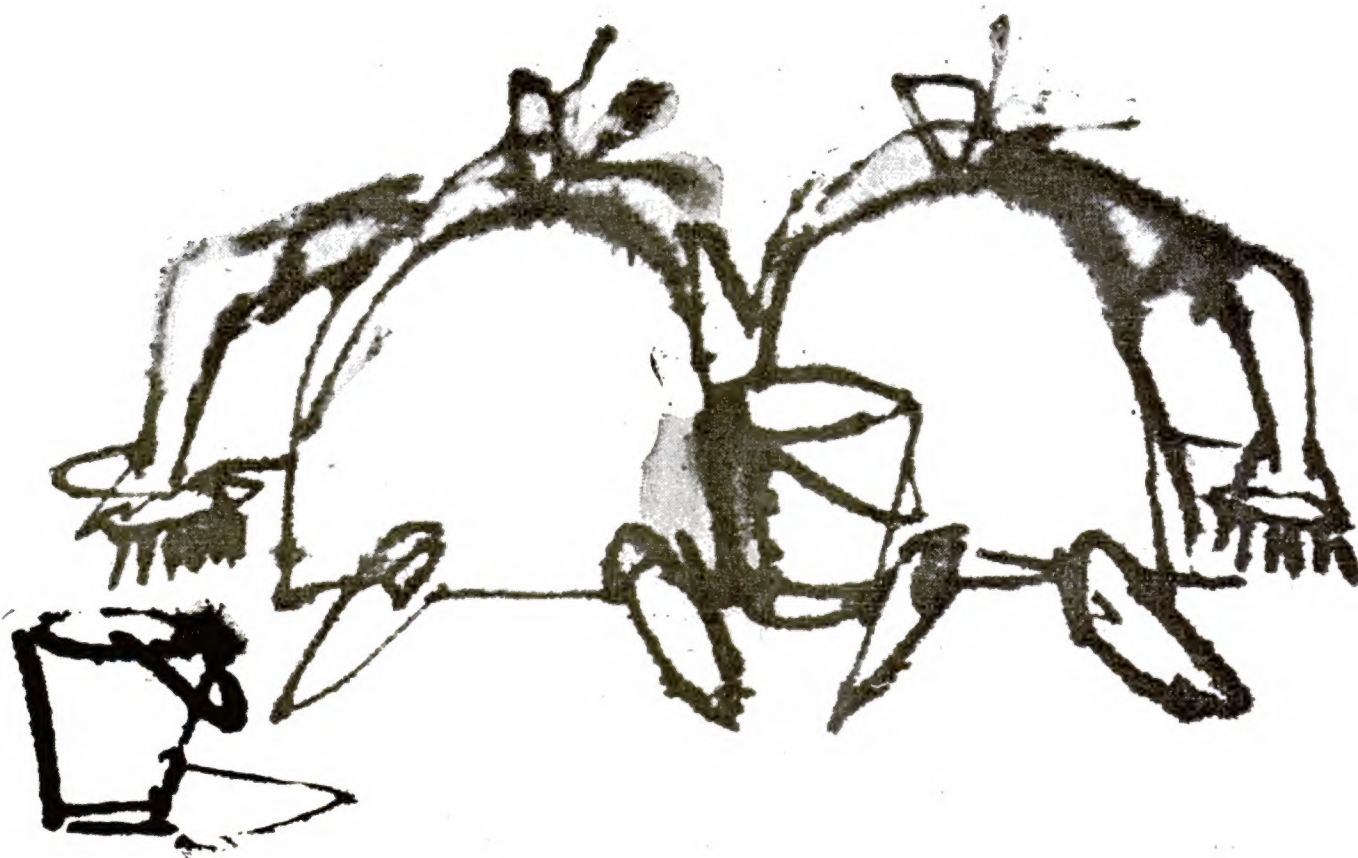
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NOTES AND COMMENTS

Radiation and Man

THE Medical Research Council's committee on the Hazards to Man of Nuclear and Allied Radiations has some reason for satisfaction, in so far as its conclusions reached four years ago, in the then prevalent state of ignorance about the effects of atomic radiation, have been largely borne out by the intensive research conducted in the meantime. Its second report, published last week (HMSO, 7s.), comes to very much the same conclusions as the first.

If anything, studies of gross effects of atomic radiation indicate that human beings are more resilient than was supposed four years ago. In particular, reports from Hiroshima and Nagasaki indicate that liability to leukaemia falls off ten years after exposure to radiation; and surveys of the effects of medical uses of radiation in Britain tend to confirm this conclusion. Again, the weight of evidence in animal experiments indicates that the effect of a small, repeated, cumulative dose is considerably less than the same total dose when it is suffered in one burst.

Moreover, the extensive studies of strontium-90 in fallout have given a tighter grip on the problem of forecasting future levels of exposure: so that the concentration of strontium-90 at which a "re-assessment of the situation" would be necessary has been raised from 10 micromicrocuries per gram of bone calcium to 33 micromicrocuries. With increased understanding of the residence of strontium-90 in the stratosphere and the mode of its introduction into human food, the committee considered itself unlikely to be caught out by a sudden rise if nuclear weapons tests were resumed.

Reassuring as all this may be, the fact remains that nearly all the progress in the last four years has been concerned with measurement of radiation and with statistical studies of its gross effects. As Dr. E. E. Pochin, the committee's vice-chairman, conceded last week, it is hard to get exact facts on the mechanisms of radiation damage. There can be no complacency about the radiation problem—either about fallout from nuclear weapons tests or in connection with the industrial and medical uses of radiation—until we know far more about what the particles and photons produced by radioactive materials actually do to the molecules of human tissue and to the code transmitted by the genes. Experimentally, this is very difficult, especially when one is dealing with the very low levels of radiation affecting the population as a whole. It may be many years before all the consequences of artificial X-rays and artificial beta-emitting isotopes in fallout have been adequately described.

Meanwhile, bodies like the MRC committee have to proceed on the assumptions that one kind of radiation is much like another, and that experiments in animals can be extrapolated to Man. The very violence of the recent disputes among scientists about the possible hazards of fallout testifies to our ignorance. The committee calls for increased support for research, and one must hope that when it publishes its next report on this subject it will be able to give its reassurances on the basis of a fuller understanding of the microscopic actions of radiation in the living human cell.

NEW SCIENTIST

A proposal for a British
communications satellite

DR. W. F. HILTON, *Science Policy Analyst*

Some curious caterpillars

BY GEORGE S. HYDE

Dislocations in crystals

BY PROFESSOR A. F. MOTT, F.R.S.

Pressure waves in internal
combustion engines

BY DR. R. E. BENFORD, *Mechanical Engineering Department, Liverpool University*

A cold look at Kariba

BY DR. PETER CROWCROFT

Darwin, Butler and evolution

BOOK REVIEW BY SIR GAVIN DE BEER, F.R.S.

VOLUME 1 NUMBER 263

ONE SHELLING WEEKLY

A new look for *The New Scientist*

FROM next week *The New Scientist* will change its name to *New Scientist*. Although this dropping of the "The" may seem a trivial departure, it will enable the title on the front cover to be much more boldly displayed, so that the magazine will be more readily recognizable by those of its readers who buy their copies at the bookstalls each week. The contents of a recent issue have been used to show, above, how the new cover format will look. The title will stand out in white against a background of blue. The contents announced on the cover, hitherto in Gill sans type, will henceforward be set in Plantin type.

These changes have been made in consultation with a leading typographer. He has also re-designed the editorial pages inside the magazine. Here the changes have been mainly concerned with the types used for headlines. The admirable Times family will still be used, but the main headlines for special articles and regular features will be set in the "bold" range of that family instead of, as at present, in Times New Roman. The typographer's aim has been to enhance the visual attractiveness and,

This One



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NOTES AND COMMENTS *continued*

therefore, the readability of the pages. With the same purpose in mind the page size is being slightly enlarged.

Plans are in hand to increase, during 1961, the scope and interest of the editorial contents themselves—without, of course, in any way altering the character of the magazine, which has become so firmly defined during the four years since its foundation.

One innovation is a weekly "Puzzles and Paradoxes" section compiled by a distinguished mathematician. He will introduce himself in next week's issue.

Hitherto two volumes of *The New Scientist* have been published yearly. Henceforth there will be four volumes a year, and the index will also be issued quarterly at 1s. 3d. a copy, post free.

Binders to hold 13/14 enlarged copies will cost 12s. each, post free (or 11s. each where four are to be dispatched together). These will be available shortly.

What happened to the Christmas tree?

SOMETHING more than a million Christmas trees (*Picea abies*) have already begun to shed their long, sharp needles on the domestic carpets of Britain. In a week or two they will be thrown out dry or replanted (with rare success) in vacant lots. The domestic regard accorded to what the nurseryman calls the Norway or common spruce is brief by any reckoning. It is worth noting that there was no Christmas tree at Dingley Dell in Mr. Pickwick's day. The popularity of the species in Britain was due to a great extent to Prince Albert's nostalgia for his native *tannenbaum*.

Although *abies* was a native tree some 10,000 years ago, there were relatively few of them in Britain between the recession of the ice and the end of the nineteenth century and they were all introduced as curiosities. Today, according to the Forestry Commission, the tree is the fourth on the list of most-planted conifers, the other three being the Sitka spruce (*Picea sitchensis*), the Scots pine (*Pinus sylvestris*) and the lodgepole pine (*P. contorta*). Nearly ten million Norway spruce were planted last year and some 3,000 lb of seed were imported from Austria. The wood is



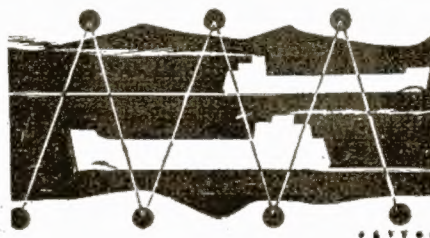
used for hardboard, plywood, box making, pulp and festive occasions.

Thanks largely to the work of the pollen analysts and phytogeographers at Cambridge, it is now possible to trace the interrupted history of the species in the British Isles. According to Dr. H. Godwin, spruce pollen has been found in almost every English interglacial deposit. After the middle mixed-oak forest stage it reached about 40 per cent of the total tree pollen in the uppermost layers of the famous Cromer Forest bed, with *Pinus* present only slightly less abundantly. What happened to it?

The answer is simply that it was displaced by climatological change. The present distribution is from the Pyrenees to Russia, but as a natural species it is absent from north France, Belgium, Holland, north-west Germany and Denmark. The tree needs cold winters, a moist soil and steadfastly avoids mild-wintered oceanic regions and valleys and depressions liable to summer drought.

Persian Gulf rivals the Channel for navigation

THIS week the southern coverage of the Decca navigation chain for the Persian Gulf area has been switched on. Henceforth stations will be operating from romantically-named places in what was the nineteenth-century pirate coast area—Aba Dhabi, Doha, Das Island and Shaikh Shu'aib. Soon the three northern stations, at Bushire, Bandar Dilam and Khosrowabad, will complete the net-



work, and will put the Persian Gulf on a par, navigationally, with the English Channel. The Gulf, and considerable areas of land on either side, will have the benefit of a system which gives accurate fixes to any ship carrying the Decca receivers and automatic course-plotters.

It was a combination of scientists and shipping men who organized this latest Decca coverage. The oil companies have for many years been using Decca to fix the locations of their geophysical experiments offshore. It was noticed by some oil company employees that the temporary chains set up for this purpose were, if the work of all the oil companies was added together, costing more than a permanent system. Furthermore, the rapidly-growing tanker movements in the Gulf made the shipping side of the oil industries conscious that improved navigational methods for routine voyages would be worth while.

Shell and BP joined forces with the Consortium which runs the oil-fields in Persia for the National Iranian Oil Company, and devised a scheme by which the cost of the installation of the Decca system should be shared by these oil companies. The owners of the system were to be the Persian Gulf Lighting Service, a non-profit-making body whose charter states that the best aids to navigation shall be set up and operated in the Persian Gulf; and an equitable scheme for all concerned was so arranged that the PGLS should subscribe an ever-increasing quota, until eventually it took over the operating costs of the system.

Normally, of course, local governments operate the aids to navigation around their own coastal waters, and no doubt the Persian Gulf border States will wish to follow this example in due course. Meanwhile, the practical oil men have got the system moving; they have shown that an international outlook is not incompatible with the interests of trading companies and their servants. The Hydrographer of the Royal Navy has the special charts ready, overprinted with the Decca "lanes", so that in future, when ships are enveloped in blinding dust storms, or when rapid helicopter rescue is needed for a distressed ship, the Decca navigational system will be there to act as guide.

NOTES AND COMMENTS *continued*

Controlling Europe's congested airways

UNIFIED control of airliners in the upper air over western Europe will probably not be realized for another two years, despite the signing this month of the Eurocontrol Convention on behalf of six States. The convention has first to be ratified by the respective governments; then an agency will have to be set up to prescribe the operational organization; and finally apparatus to serve the control system will have to be obtained.

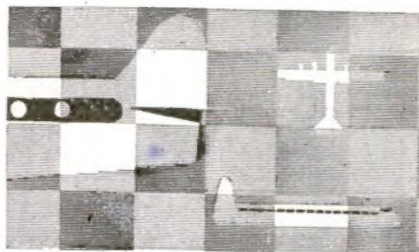
In broad outline the nature of the project is clear enough. There will be four, possibly five, zones in which all aircraft, civil and military, if they are using or crossing commercial airways at heights above 25,000 ft, will be subject to control. That is to say, they will be ordered to fly at a particular height or to change their height and, in a critical situation, they may be required to change course or to circle. In this control system, civil and military control (at present coordinated in most European countries) will be integrated.

How thick the traffic at those heights will be and where the worst congestion is likely to occur cannot at present be foreseen with any precision, and the system will need to be flexible enough to embrace unexpected developments and to allow for seasonal peaks. What seems quite certain is that, with the speed of modern jets, new apparatus will become essential at the control centres.

Radar, with its present range of 250 miles for high-flying aircraft, should suffice, since it can be supplemented by the handing over of traffic by controllers from one zone to the next, but specialized radar may prove to be needed. The particular essential will be computers which can keep track of all the aircraft moving through a zone; and so far as is known, the right type of computer has not yet been found. The demand is probably too small to justify a manufacturer in designing a computer for this particular kind of work.

The signs are that four of the control centres will be at London, Prestwick (near Ayr), Paris and Brussels, with interlocking arrangements for all of them. The territories to be covered

are: Britain, France, Belgium, West Germany, Holland and Luxembourg. This area covers the worst points of convergence for the fast jets moving both ways from the Atlantic eastwards and from Asia and Africa westwards. Into that area some 300 of these liners are likely to be operating by the end of 1961. The need for Eurocontrol is obvious. The desire that it should extend farther to the south and the east is understandable.



In deciding to make a start, the six signatories of the convention have accepted a commendable piece of pioneering. When the system is equipped with proper apparatus and its officers have gained some experience, it should make a valuable contribution to safety in what is likely to be one of the most crowded bits of sky outside the United States.

What makes a good potato?

DIFFERING tastes among potato eaters, and the wide range of desiderata specified by producers and users, make definition of quality in potatoes a peculiarly complex problem. As an American author has declared: "Good seed of any variety grown under good conditions will give good quality potatoes—but some do better than others." In a concerted attempt to sort out the implications of this statement, farmers, scientists and agricultural advisers recently spent a day discussing the theme of quality in potatoes, at a crop conference organized in Cambridge by the National Institute of Agricultural Botany.

Absence of external and internal damage is one important criterion of considerable economic importance to the farmer. A survey carried out in East Anglian potato crops in 1959

showed that only one in three of the tubers left the field unscathed. Further serious damage occurred during transit into store, reducing the undamaged portion by another 10 per cent. By the time the tubers were sold, only two in three of those put into store were saleable, due to the combined toll of rotting, shrinking, sprouting and damage from mishandling.

On present evidence, it seems that although there is little prospect of appreciable reduction in damage by further improvement of harvester design, greater care in operating these machines and in the way the tubers are handled subsequently could markedly reduce losses and improve quality.

German research has shown that potatoes differ in their resistance to injury, depending on soil and climatic factors and on variety and state of maturity at harvest. The National Institute of Agricultural Engineering is using a German-designed machine for investigating the relationship between skin toughness and susceptibility to damage in different potato varieties. It rather looks as though breeding a variety with a tougher skin would help.

Besides appearance, cooking quality ranks high in the tests used by the NIAB for assessing new varieties. The percentage of dry matter in the tubers is a useful yardstick, for a relatively high value indicates flouriness, and absence of the tendency to take up unduly large amounts of fat during frying or crisping. The introduction of a grading system based on dry matter content, as used in the United States, to separate "boilers" from "bakers" would ensure greater uniformity in the cooked product than is obtainable by visual grading alone, for the natural range of variation may be as high as 14 per cent between individual tubers in the same sample.

Although the extent of after-cooking discoloration is now known to be the result of competition between chlorogenic and citric acids for iron in the tuber tissues, the field conditions that discourage the formation of tubers likely to develop this bad quality cannot yet be formulated. Plant breeders may sidestep the problem by developing non-blackening varieties. But research into the fundamental biochemistry of the phenomenon continues at the Low

NOTES AND COMMENTS *continued*

Temperature Research Station, and is at present concentrated on elucidating the role of different plant nutrients in the formation of citric and chlorogenic acids in potato tubers.

Demands of fashion stimulate pearl hunting

A CHANGE in fashion that has revived the demand for natural pearls is having a profound effect on the lives of the Indian pearl divers whose hunting grounds lie along an 80 mile stretch of coast in the Gulf of Manaar. For many years India's pearl industry languished, because fashionable women preferred cultured pearls to natural ones. But now its prospects are improving, for the numbers of fishable pearl oysters off the Indian coast are unaccountably increasing, just at a time when the soft glowing colour of natural pearls has brought them once more into favour.

Determined to re-establish the pearl industry on a scientific footing, the Indian Government asked the Food and Agriculture Organization to send along a marine biologist to survey the pearl beds. The expert chosen—Dr. Francesco Baschieri-Salvadori, of the Rome Zoological Gardens—is an expert diver. His first task was to decide on suitable underwater equipment. The discovery that poisonous snakes share the oysters' quarters convinced him that it would be prudent to wear a thick rubber diving suit in addition to face masks, fins and aqualung.

Thus clad, he and his team of Indians have already charted the pearl beds, and collected much valuable chemical, physical and biological data underwater. During the next three months, before the local oyster season opens in February, they intend to pinpoint the best beds and to use an echo-sounder to check on the existence of any promising pearl banks that may have been missed in the initial explorations.

At the same time they are investigating chank beds, which yield a large white spiral shell used for rings and other jewellery by the women of Bengal. These shells are also included in the headbands worn by the sacred Hindu cows. Chank fishing has considerable economic importance, and since it can be practised when the



water is not calm enough to allow the divers to search for oysters, it is complementary to pearl fishing.

Peaceful science for schoolboys

A NOVEL experiment in scientific education is on show at this year's Schoolboys' Exhibition at Olympia. It is called "Science for Life" and emphasises the peaceful and constructive use of science in frank contrast to the type of scientific project which usually occupies the minds of small boys—and regrettably also of governments.

A group of scientists—chiefly from University College, London—thought up the idea and passed it on to the Society of Friends, who put it into effect. The stand (No. 20B) can be recognized by the silver sputnik above which reflects a number of searchlight beams. Immediately inside the visitor comes face to face with an illuminated transparency of a young mother and child which fades as he approaches it into a skull surmounted by a mushroom cloud, and the question "Science for life or for death?"



Research workers of the University of London have contributed most of the scientific demonstrations, which are divided into four bays.

The first deals with power, exemplified by a solar battery driving a motor, a working plasma "pinch" system, and a demonstration of radioactivity. A "do it yourself" element increases the appeal of these exhibits. Boys are able to interrupt the beam and thus stop the solar motor with their shadow; to bring a magnet close to the plasma tube and see the "pinching" of the violet discharge; or to open a shutter and release radioactivity for either good or ill. Here the choice is underlined by backgrounds showing either the medical uses of isotopes or, alternatively, the ruins of Hiroshima, which light up as one or other button is pressed.

A bay devoted to "Life" contains microprojections of living *Daphnia*, of chromosomes before and after radiation damage, and of a giant model of DNA. There is also a fitness test in which a volunteer sits in a chair and by grasping two handles can see and hear his muscle contractions, heartbeats and other physiological potentials. The disembodied voice that follows the visitor round from bay to bay reminds him that if he is fit, two-thirds of the world's population are not—chiefly through protein deficiency and preventable disease.

"Food" comes next, introduced by a "fish farm" with living carp and the reminder that while we no longer hunt sheep or search for wild corn, our approach to the food resources of the sea is still at the primitive, food-gathering stage. This is followed by a pilot-scale plant for the culture and harvesting of *Chlorella* as a protein source; the thick green concentrate, containing 60 per cent of proteins and rich also in vitamins, can be seen running out continuously. The voice draws a pointed contrast between lavish expenditure on bombs and the beggarly amounts devoted to human welfare.

The final bay shows rockets as implements of peace—a model takes off and fires its flash grenades, while the genuine flash-detectors, radar and telemetering devices, used in meteorological research, track it. Alongside it is the nuclear missile. Finally the display repeats the alternating symbols of the mother and the skull as a tailpiece.

1960 SCIENCE SURVEY

Advances this year which show high promise for the future are discussed

Professor H. M. Barlow
Sir John Cockcroft, OM, FRS
Sir Henry Dale, OM, FRS

M. James Lighthill, FRS
Sir Harrie Massey, FRS
Professor S. K. Runcorn
Dr. M. H. F. Wilkins, FRS

RADIO and ELECTRONICS: new techniques developed

THE year has been a notable one in the development and application of new techniques for radio communication and electronic purposes.

At the International Scientific Radio Union meeting, held at University College, London, last September, we heard of the first successful use by American scientists of artificial satellites as a means of reflecting back to Earth ultra high frequency radio waves, thus enabling them to be employed for long-distance communications. The naturally occurring reflecting layers of electrons and charged particles surrounding the Earth at heights of from 50 to 200 miles have for many years been exploited in this kind of service using waves of lower frequency and, more recently, advantage has also been taken of regions considerably closer to the Earth which scatter and return to the ground a small fraction of the energy transmitted.

The *Echo* satellite, which was launched by the Americans for communication purposes, is a plastic balloon of 100 feet diameter, metalized on the outside and travelling at a height of about 1,000 miles above the Earth. This man-made reflector is capable of providing for transmission around the Earth's surface over much greater distances, and in a test of its capabilities President Eisenhower was clearly heard speaking some 3,000 miles across the American continent. The next step, which may be expected in the near future, is clearly to put into orbit three or more satellites, suitably located in height and spacing to enable continuous signals to be transmitted around the Earth from one place to another wherever these



may be, and to make the system more effective by arranging to re-transmit the signals at increased strength when relayed from a satellite. Instrumented satellites have provided a new research tool to radio scientists for the exploration of space surrounding our Earth and by this means much new and exciting information is being gathered together.

The rapid extension of free-space radio transmission and the accompanying growing congestion of the aether has emphasized the need for screened channels of communication wherever possible. During the year the British Post Office called attention to its work on tubular waveguides as another means of achieving greatly extended facilities for long-distance communications, and announced its confidence in the future application of this system.

The progress made in radio communications would not have been possible without corresponding achievements in the associated electronic

equipment. Indeed, these two aspects of the work are so closely allied as to be mutually dependent upon one another. Microwaves play the vital part in these exciting developments, and the perfection of such devices as masers, parametric amplifiers and travelling wave tubes for dealing with very weak signals has had a profound influence on most of the techniques used.

No less valuable has been the introduction of arrangements for converting solar energy into electricity so as to provide for a continuous supply of power in instrumented satellites. As a possible means of supplying electricity in large quantities on the ground, the thermo-electron engine is being given close attention, and there is reason to hope that in due course it may supplant the present rotating generators. Efficiencies for direct conversion from heat to electricity as high as 15 per cent have already been achieved. The reverse process, in which heat is extracted by the flow of an electric current through a semi-conducting alloy, has also been successfully demonstrated and refrigerators employing this arrangement will, no doubt, soon become available to the public.

The remarkable progress which is continuing to be made year by year in radio and electronics is having a very notable effect not only on our daily lives but also on our knowledge of conditions outside the Earth's surface. Vastly improved communication facilities form the keynote to the transformation which is taking place, and with it comes a real hope of better understanding between the peoples of the world.

H. M. BARLOW

1960 SCIENCE SURVEY *continued*

AERONAUTICS: a year of notable achievements

IT is hard to pick out, as the editor has requested, three areas of maximum growth rate in the wide, ever expanding field of aeronautics; but, with apologies to those making striking progress in areas that have been omitted, here is my selection.

Supersonic Airliners. Long-distance travel is becoming easier, to the benefit of international understanding, in jet airliners cruising at 600-700 m.p.h. The next step may well be to aircraft at least twice as fast.

Why is this? It is because the airliners entering service in 1958-64 are essentially traditional designs, modified to push up the speed at which substantial shock-wave resistance appears, from (say) 500 m.p.h. to the design cruising speed. To push farther is uneconomic. A completely new design is preferable, aimed at "living with" shock-wave resistance and exploiting the rapid increase of turbo-jet efficiency with speed.

This suggests a narrow-delta shape, whose upper speed limit may be set mainly by aerodynamic heating of the airframe, at perhaps 1,400 m.p.h. for aluminium alloy. Such shapes will acquire adequate lift for take-off and landing by a new principle, in which "ice-cream cornet" vortices are shed from a sharpened leading edge.

Some passengers would doubtless be willing to pay above economy-class rates to travel twice as fast. However,

extensive studies by the Royal Aircraft Establishment and most of the British aviation industry from 1956 onwards, including the work which led to the recently announced award of a design study contract to the British Aircraft Corporation, have indicated that the economics of this 1,400 m.p.h. aircraft should be very little dependent on any such willingness.

This economic attraction would be absent with the widely canvassed alternative of a steel aircraft, according to current British views. Thermal degradation of its non-metallic materials would limit its cruising speed to about 1,800 m.p.h., so that only 20 minutes would be saved on (for example) a transatlantic run, at a substantial additional cost, which BAC's experience on the steel high-speed research aircraft Bristol 188 has well qualified them to assess.

Vertical Take-off and Landing. It is still controversial what are the proper domains of application of vertical take-off and landing, although the earliest, doubtless, will be military, as were those of supersonic flight. In the meantime, 1960 was a notable year in the current, experimental phase.

First the Short SC.1, using separate jet engines for lifting and propulsion, demonstrated publicly the remarkable effectiveness of automatic stabilization by subsidiary jets at its extremities, during transition from jet-borne to

wing-borne flight and back into the hovering condition.

Later, the Hawker P.1127, using only a single turbofan engine, the direction of whose efflux is varied by means of special swivelling nozzles to provide either lift or thrust, or both, passed successfully its first hovering tests, and we may look forward now to its transition to wing-borne flight, stabilized in a manner similar to the SC.1.

Very-low-frequency Radio Navigation. Radio waves of length about 20 kilometres are propagated around the Earth, using the space between its surface and the ionosphere as a waveguide. Huge transmitters on these wavelengths exist at Rugby and Panama.

Great progress has been made in 1960 in proving a navigation system for aircraft, based on these transmissions. Changes of phase in a received signal, relative to that of a stable oscillator in the aircraft, have been used to determine changes in distance from the transmitter with good accuracy over truly long-distance routes, such as Farnborough to Nairobi.

If further evidence shows that accuracy remains consistent, one can look forward to a system of worldwide navigation using at most six ground stations.

M. J. LIGHTHILL

ATOMIC SCIENCE: powerful experimental tools

MAJOR advances in high energy nuclear physics are likely to result from the bringing into commission of the 28 billion volt proton synchrotron at CERN, Geneva. The accelerator has already produced beams of particles of an order of magnitude more intense than the design figure and experimental work has been proceeding throughout the year.

The passage of 25 BeV protons through a chamber filled with liquid hydrogen produced large numbers of K-mesons and anti-protons. The K-mesons of low energy were between 10 and 30 per cent of the abundant π -mesons, and the anti-protons were about 1 per cent of the π -mesons. So

the accelerator will be an excellent source of these particles for experimental work.

A surprisingly large number of deuterons, tritons and helium-3 nuclei of high momentum was also produced from a target inside the machine, and the mechanism for this is not yet understood.

The production of high energy neutrinos from the decay of energetic pions produced in the CERN proton synchrotron may make it possible to study interactions between neutrinos and atomic nuclei, since the interaction of neutrinos with nuclei should increase rapidly with increasing energy. There is likely to be in general a considerable increase in experimen-

tal work on "weak interactions" with a view to seeing whether these interactions become much stronger with increasing energy.

Muons produced in the decay of positive pions have been shown to spin in the left-handed sense about their direction of motion. Muons from negative-pion decay have been shown to be right-handed, thus confirming predictions on weak interactions.

The scattering of pions by nuclei, resulting in polarization, has been compared with theoretical predictions in several laboratories and the forces at distances beyond 3×10^{-13} cm. are now well understood, whereas the behaviour in close collisions, associ-

ated with multiple meson production is not yet completely understood.

Interesting experiments have been performed with relatively simple equipment to study the acceleration of photons in the Earth's gravitational field, and so to confirm the gravitational red shift. A large proportion of the gamma rays emitted by the radio-isotope iron-57 have been shown to have an extremely narrow line width due to the Mossbauer effect—the effect of the recoil of the atom being taken up by the whole crystal. The photons are counted after falling several tens of metres through the Earth's gravitational field so that the frequency is increased. By vibrating the gamma ray source up and down to

produce a Doppler shift it is possible to measure the gravitational shift, and this turns out to be in accordance with predictions after correcting for temperature effects. The technique now makes it possible to measure the intense magnetic fields near nuclei in crystals, since these fields cause splitting of the gamma ray lines. The Mossbauer effect should therefore be a powerful tool for studies in ferromagnetism, anti-ferromagnetism and other solid state problems.

Experiments on the production of high temperature plasmas for controlled thermonuclear fusion at Livermore, California, using double compression to heat up the plasma in a "mirror" machine, have shown that

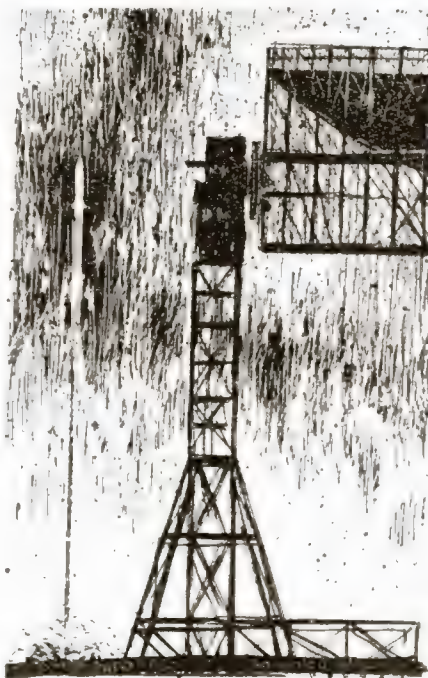
ion temperatures as deduced from velocities of escaping particles reach 30 million degrees K, whilst electron temperatures are between 200,000 and a million degrees. A third stage of compression which will be introduced shortly may increase ion temperatures to the region of 100 million degrees, with a plasma density of about 10^{14} particles per cubic cm. These experiments are especially important in showing that so far the plasma has remained stable. Most other plasma experiments have been in difficulty with instabilities during the year, but there has been a welcome growth of theoretical understanding of some forms of instability.

J. D. COCKCROFT

SPACE RESEARCH: the dividends are just appearing

THE year 1960 has been one of much activity in space research and related subjects. Undoubtedly the Russians stole the limelight with their remarkable recovery of the two dogs from a satellite vehicle in which they had made a number of revolutions around the Earth. This demonstrated that the problem of re-entry into the atmosphere, one of the most difficult of all, was well on the way to being solved. All that is necessary for it to be reliable would seem to be more experience—the unfortunate dogs which made the same journey a short while ago did not return. It must be mentioned also that, during the year, the Americans made a number of successful recoveries of nose cones from orbiting, or near orbiting, vehicles, albeit rather smaller vehicles than those of the Russians. Undoubtedly rapid progress is being made, but there is some time to go yet before the whole operation is reliable enough for a man to undertake it.

In many ways, however, the most extraordinary feat of the year in space research was the long-distance communication test carried out with the American *Pioneer V* space probe in conjunction with the radio telescope at Jodrell Bank. This probe carried two radio transmitters. Signals from the less powerful of these were received until the probe had reached a distance of nearly eight million miles from the Earth. At that stage the more powerful transmitter was switched on by a command signal from Jodrell Bank. Signals were received from this



transmitter until the probe had travelled to a distance of no less than 22½ million miles. During the time when it was in communication this remarkable space craft sent back scientific information of much interest about solar particle radiation and the Earth's magnetic field. The whole enterprise presented an astonishing demonstration of the effectiveness of modern methods of long-distance communication.

Much progress was made during 1960 in carrying out meteorological

observations from satellites. In April, *Tiros I* was launched by the USA, a vehicle fully equipped to make observations of cloud cover and atmospheric disturbances generally. An abundance of information is coming from this and other meteorological satellites, and the problem is to set up an effective world-wide organization to take full advantage of it all. As with all satellite studies, a major problem is to arrange for adequate processing of the enormous amount of data which is obtained during months of observation with airborne equipment.

Although no scientific results of striking importance have been forthcoming from space research in 1960, a great deal of steady progress has been made in many directions. The study of the van Allen radiation belts and their relation to the solar disturbances and to the Earth's magnetic field is expanding rapidly and shows how much we have yet to know about these aspects of solar-terrestrial relations. International cooperation on the scientific work is steadily improving, and at the beginning of December, ten European nations, including Britain, signed an agreement to set up a preparatory commission to examine ways and means of setting up a European cooperative organization for space research. The scientific dividends from space research are just appearing. We must expect a continual growth as the scope of the work expands.

HARRIE MASSEY

1960 SCIENCE SURVEY *continued*

MEDICINE: benefits from scientific cooperation

THE year 1960 has seen a continued development of the newly cooperative relationship through which the experimental disciplines of biology and medicine are becoming permeated and reinforced by methods and standards which, until recently, had seemed to belong only to the more fundamental ranges of physics and chemistry. The subatomic revolution in physical conceptions and the development of electronic instrumentation are transforming, to a degree which until recently seemed beyond hope of attainment, the methods available to biology and medicine for the recognition of structures and the measurements of dimensions. Biological agents and phenomena, such as viruses, inheritance or immunity, seem now to be coming within the range of molecular physics and chemistry; while such reagents as radioisotopes are becoming almost familiar tools of research to the physiologist and the clinician. A few examples may illustrate these momentous changes.

Radioactive isotopes of gases, most recently oxygen-15 and carbon-dioxide containing it, may now be used for studying directly the comparative respiratory functions, and the rates of blood-circulation, in different parts of both lungs in the conscious human patient, who inhales them in appro-

prate dilutions without discomfort. These short-lived isotopes have to be prepared and used immediately, as by the cyclotron provided by the Medical Research Council for the Postgraduate Medical School at Hammersmith.

The MRC Unit for Research on the Common Cold, at the Harvard Hospital, Salisbury, has isolated several viruses responsible for such infections, growing them on artificial cultures of human tissue cells. And the discovery of a directly harmful effect of such a virus, on the cells of a culture which it thus infects, opens the way to further progress, without the previous need for human volunteers at every stage.

Another virus, or group of such, in the study of which important progress has been made at the Lister Institute, is that now proved to be responsible for the infective disease of the eyes so terribly common all over the tropics and known as "trachoma". If an effective means of preventing or curing this affliction could be discovered, it ought to bring relief from deprivation and misery beyond the range of computation.

A good beginning has also been made in the identification of chromosomal abnormalities, responsible for genetic defects in Man. The number of chromosomes normal for a human somatic cell being now known to be

46, it appears, for example, that an extra chromosome is present in the cell of a sufferer from the inborn anomaly known as "mongolism".

Workers at the National Institute for Medical Research have recently developed a "radio-pill", containing a minute radio-transmitter, which can give diagnostically valuable evidence of the movements of a hollow viscus, in which the "pill" has been lodged by swallowing or otherwise.

And mention may be made of a device developed by surgical research in Birmingham. In this a subcutaneously planted capsule, containing a recipient coil connected with electrodes implanted in the heart, enables a patient suffering from a complete block of the normal auriculo-ventricular conduction to maintain a regular, artificial rhythm of the ventricle by impulses from an external transmitter, and even to vary its rate in accordance with need created by exertion.

These are but a few examples of the extent to which physics and chemistry on the one hand, and experimental biology and medicine on the other, are now sharing knowledge, interest and reciprocal stimulus, for the promotion of fundamental knowledge, and therewith of the resources available to medicine for the benefit of human health. H. H. DALE

MOLECULAR BIOLOGY: advances in protein chemistry

MOLECULAR biology continues to make considerable advances, especially in elucidating how protein macromolecules are formed with the highly special structures and specific chemical properties that enable living processes to proceed rapidly and correctly. This year's outstanding achievement is the determination for the first time of the three-dimensional structure of a protein molecule. The protein is myoglobin—the substance that stores oxygen in muscle. The molecule contains 1,200 atoms apart from hydrogen. The structure determination was made by means of X-ray diffraction analysis after 12 years of concentrated effort in the Medical Research Council Unit for Molecular Biology in Cambridge.

This is a great triumph of protein chemistry and also one of the greatest

successes of the X-ray diffraction method. In the structure almost every amino acid can be identified in the polypeptide chain, and where the position of an individual atom cannot be seen directly it can be inferred with the aid of molecular models. The significance of the structural detail is mostly not yet clear, but the possibility now exists of interpreting protein function in terms of structure and obtaining answers to such questions as: how are the catalytic properties of enzymes related to the coiling of their polypeptide chains?

Steady progress has also been made in understanding how nucleic acids control the synthesis of proteins. Incorporation of radioisotopes into cells shows that proteins are probably synthesized in ribosomes—small particles composed of nucleic acid and protein

in the cytoplasm. When the synthesis begins, a new type of RNA (ribonucleic acid) is also synthesized and appears in the ribosomes. Indications are that this RNA is formed in the nucleus of the cell. The hypothesis is that the new RNA is formed by template action on the surface of DNA molecules in the chromosomes of the nucleus and then carries in its molecular structure the genetic code from the DNA to the seat of protein synthesis. The new RNA has been called Messenger RNA. While Messenger RNA arranges the amino acids in the correct sequence in the protein molecules being synthesized, another type of RNA, Transfer RNA (sometimes called "Soluble" RNA), carries each amino acid over the barrier of incorporation into the protein. Much remains obscure, but the steady accumu-

lation of new data is enabling a clear picture of protein synthesis to emerge and we may hope in a few years to understand how the amino acids are joined together and coiled up in the complicated manner now seen for the first time in the myoglobin molecule.

Molecular biology continues to grow in popularity and prestige; but its development in Britain has not been without difficulties. The subject lacks academic tradition. As a result, the universities, with a few notable exceptions, have not given adequate

attention to molecular biology, and growth of the subject has to a large extent been possible only because of the enlightened support of the Medical Research Council.

Fortunately in this year important steps have been taken to consolidate the position of the two leading British laboratories of molecular biology and establish them in adequate accommodation. In Cambridge there will be a new building for the Medical Research Council Unit for Molecular Biology. In the University of London plans are well advanced to provide

(with Wellcome Trust aid) a building to house together the newly-formed Biophysics Department of King's College and the Medical Research Council Biophysics Research Unit.

These developments are most encouraging, but it is anomalous that, while British molecular biologists are leading the world in several important fields, the incorporation of molecular biology and biophysics into the framework of most British universities has barely begun. In this respect we lag behind the United States.

M. H. F. WILKINS.

EARTH SCIENCES: evidence for continental drift

AN important trend during 1960 in the Earth sciences has been the new readiness of geophysicists and geologists to look again dispassionately at the evidence for polar wandering and continental drift. It is nearly fifty years since Alfred Wegener suggested that the continents were once gathered together in two great land masses and had drifted apart in the last 100 or 200 million years. Wegener made this revolutionary suggestion on qualitative grounds, using evidence of palaeontological and other similarities between the geological deposits near the coastlines now separated by oceans. The theory gradually lost ground, mainly through attacks from geophysicists who thought that our knowledge of the Earth's interior was sufficiently complete to exclude the possibility of continental drift.

In the last ten years the ancient directions of the magnetic field of the Earth, inferred from the remanent direction of magnetization of rocks of different ages, have enabled the positions of the continents with respect to the axis of rotation at different geological times to be quantitatively determined. As with all new developments in science, considerable controversy has been aroused by the application of geomagnetic methods to polar wandering and continental drift, for it has seemed remarkable at first sight to many that the extremely weak magnetization of sedimentary rocks and lava has remained unchanged over hundreds of millions of years and that the magnetic field itself can be definitely related to the position of the axis of rotation. However, indications that this new and powerful method demonstrates continental drift

are being increasingly accepted; for example, the American geologists organized last Easter the first symposium on continental drift they had held since 1928, and further discussions on the subject were held at the International Union of Geodesy and Geophysics at Helsinki. Also during the year there have been three papers published reviewing the palaeomagnetic evidence which show very clearly its self-consistency.

One major oceanographic discovery announced during the year is relevant to this topic. The Scripps Institution of Oceanography, California, has for some years been measuring the total magnetic field over the NE Pacific. (As in similar surveys made on land, magnetic anomalies reflect differences of magnetization in the basic rocks of the upper part of the Earth's crust.) Dr. Victor Vacquier has found that the results could only be interpreted by postulating transverse movements along E-W faults in the area amounting in total to 1,400 km. There are, of course, many faults in the continents along which transverse movements of many miles are known. The movements inferred from the magnetic surveys, however, represent horizontal displacement of the Earth's crust similar in magnitude to those postulated in continental drift theories.

Another interesting development has been a study of an electromagnetic model of the Earth's core which has shown how reversals of the poles of the Earth's main magnetic field may have occurred. Early studies in rock magnetism surprised many people by indicating that the polarity of the geomagnetic field has changed several

times at intervals of a few million years. Dr. F. J. Lowes, of King's College, Newcastle upon Tyne, and Dr. H. Matthews, of the Naval Research Laboratory at Washington, both announced studies of the spontaneous oscillations of two simple, coupled dynamos. They found that the current and velocity of the dynamos oscillate and from time to time the oscillations become so great that the currents reverse. One interesting feature of these systems is that the time interval between successive reversals varies widely—it has no fixed period as in many simple oscillators. This appears to fit in quite well with the results of rock magnetism in which the frequency of the reversals seems to vary considerably through the geological column.

A striking confirmation of theoretical calculation has occurred during the year in the determination of the various periods of free oscillation of the Earth, when it rings like a bell with seismic waves. The longest had been calculated to be 54 minutes from knowledge of the variation of the elastic constants and density of the Earth obtained in seismological studies. During the Chilean earthquake these free oscillations were excited, and detected both by long period seismographs and by gravimeters. This work was done by Dr. Press of the California Institute of Technology and Dr. L. B. Slichter of the University of California and their colleagues. The analysis of the long time series (the vibrations continue for a week) shows agreements between theory and observation to within about a minute.

S. K. RUNCORN.

JULES VERNE'S *LUNIK*

From a launching site only a hundred miles from Cape Canaveral, a space vehicle containing three men, two dogs and some chickens made a circumnavigation of the Moon. But its observations of the lunar surface were understandably inconclusive

by NIGEL CALDER

TO one of the craters discovered in the photographs of the back of the Moon transmitted by *Lunik III* the Soviet astronomers have given the name Jules Verne. This singular tribute to a Western novelist is in recognition of the bold, but not altogether far-fetched, fantasy *From the Earth to the Moon* and its sequel *All Around the Moon*, which he wrote ninety years ago. Since my return from the conference on the Moon held in Leningrad by astronomers of several nations, which I reported last week, I have been re-reading these books in the light of current activities in space and lunar research: and a very rewarding pastime it has proved.

Recapitulating the outline of the project, many readers will remember that an aluminium manned capsule was fired from a cannon 900 feet long cast in a vertical well, with the object of striking the lunar surface. The party consisted of J. P. Barbican, President of the Baltimore Gun Club, Captain J. D. McNicholl, an armour-plating expert from Philadelphia, and M. Ardan, a French adventurer. In charge of ground support operations was J. T. Marston, Secretary of the Gun Club.

As the result of a near collision with a small natural Earth satellite 5,000 miles above the Earth, the projectile was deflected slightly off course, so that it missed the Moon, passed around the back from the north to the south pole and returned to Earth, despite the attempts of the occupants to force a landing on the Moon by means of retro-rockets. The projectile smashed the bowsprit of the survey ship *Susquehanna* 250 miles from the Californian coast, and dived into deep water. Having positive buoyancy, it eventually bobbed to the surface, where the occupants were recovered by Marston and the *Susquehanna* a fortnight later.

The most remarkable thing is that the site chosen by Barbican (or Verne) for the launching site was at Tampa,

Florida, only a hundred miles from Cape Canaveral. The most satirical thing is the account of the international subscription launched to finance the project. The French, the Russians, the Turks, the Swedes all gave generously, but "England did not send the United States as much money as would jingle on a tombstone". The Greenwich Observatory had denied the possibility of success, and the English refusal of money was based on "the dignified principle of strict 'non-intervention'".

"It was so well known that England never interfered on any account in the affairs of other countries—witness India, Italy, Spain, Ashantee, etc.—that however willing she might feel under other circumstances to show her friendship for her trans-Atlantic Anglo-Saxon cousins, the brothers of her Shakespeare, etc., she could not compromise her honour by departing in the slightest degree from the grand principle which it had been always her glory unswervingly to pursue."

But the Irish gave £11,625, and with total subscriptions of nearly \$5½ million the project went rapidly ahead. With what blithe confidence figures scribbled out in a few moments were transformed into hardware! There was a disquieting moment, for example, when Barbican realized, in mid-flight, that the calculated initial velocity had not included an allowance for the friction of the atmosphere: fortunately, the charge of 400,000 lb of gun cotton used to fire the projectile had also given a greater thrust than expected. Some obstacles were lightheartedly dismissed: atmospheric heating on exit and re-entry obviously presented no great difficulty because the projectile passed through the atmosphere so quickly.

Barbican took other problems more seriously. When Ardan arrived from France with the proposal that what had been intended as an empty projectile should in fact carry a man (himself), and Barbican and McNicholl settled a

bitter argument by deciding to accompany him, a preparatory experiment was arranged to test the effect of the concussion of firing. A cat and a squirrel were fired in the shell of a 32-inch mortar, to an altitude of 1,000 feet. After the shell had fallen in the sea, divers recovered it, and the cat was found to be not a particle the worse for her aerial flight.

"But no squirrel made his appearance. They waited for him. They looked for him. They shook the shell, and turned it upside down. No squirrel. There was no mincing the matter. The cat had eaten up her fellow traveller."

So animals figured prominently in Verne's space experiments. According to him, the first space dogs were not Laika, or Strelka and Belka, but Diana and Satellite, who accompanied his three human Moon voyagers, along with some chickens that Ardan smuggled aboard with the idea of setting them loose on the Moon to astonish his friends. Unfortunately, Satellite was killed by the violence of the launching, in spite of the hydraulic shock absorber Barbican had devised for the floor of the projectile. In an alarming operation, when the projectile was in the vacuum of space, the occupants calmly opened the floor light and flung the dog's body out, "with the utmost care and dispatch, so as to lose as little as possible of the internal air". Satellite then travelled alongside the projectile "like a rocket".

One important matter which Verne understood but imperfectly was "weightlessness". Every schoolboy of the 1960s knows that a space vehicle in full flight is falling freely and that weightlessness is a prolonged phenomenon. Verne believed it occurred only at the neutral point of gravity between the Earth and the Moon, and allowed only an hour of it. Nevertheless, he makes the most of the opportunity.

"Let us take graceful attitudes!"



Better than Pullman comfort.



Weightlessness.

cried Ardan, "and imagine we are playing tableaux! Let us, for instance, form a grand historical group of the three great goddesses of the nineteenth century. Barbican will represent Minerva, or *Science*; the Captain, Bellona, or *War*; while I, as Madre Natura, the newly born goddess of *Progress*, floating gracefully over you both, extend my hands so, fondly patronizing the one, but grandly ordering off the other, to the regions of eternal night! More on your toe, Captain! Your right foot a little higher! Look at Barbican's admirable pose! Now then, prepare to receive order for a new tableau! Form group à la *Jardin Mabille*! Presto! Change! . . . Oh! if Raphael could only see us!"

About the nature of the lunar surface, when explorers are close enough to observe it, Verne is reserved. He clearly inclines to the general opinion that there is no life on the Moon and that the lunar features were made by the actions of volcanoes long extinct. Still, he allows glaciers, an active volcano on the reverse side of the Moon, and possibly, glimpsed by the light of

a bolide, "real oceans". There is plenty of argument among the three men; Ardan, particularly, is convinced there is evidence of life.

"See the ruins on that bluff," he exclaimed; "those steep sides must have been washed by a great river in the prehistoric times. . . . As I'm a living man I have no difficulty in discerning the gigantic butments of a great bridge. . . ."

His companions "content themselves with saying that the reason why they had failed to discover the wonderful city was that Ardan's telescope was of a strange and peculiar construction. Being somewhat shortsighted, he had had it manufactured expressly for his own use, but it was of such singular power that his companions could not use it without hurting their eyes."

Although we may scorn the idea that the Moon could ever have supported an advanced form of life, we know little more for certain about the nature of the lunar surface than Verne did, and we cannot but respect his cautious discussion of a tricky subject—which modern science fiction writers might well study. He contrived to be restrained in his

opinions without letting enthusiasm wane.

Nor did he ever allow his adventurers to lose their dignity. "Ardan had by no means exaggerated when asserting that even the Pullman cars on the Pacific Railroad could not surpass the projectile vehicle in solid comfort." The cabin was lighted and heated by gas, and potassium chlorate provided the oxygen. They consumed beefsteaks, tea and *Chambertin* (not forgetting a "very toothsome pie" for the dog); and at the moment of crisis on the return journey Ardan produced some bottles of *Tokay Imperial 1863*.

The man who sets out for the Moon a few years hence will indeed be fortunate if, after the rigours of his selection and training, he will still be able to live up to the high standards of deportment set by the voyagers of ninety years ago, and if there is room in his capsule for bottles of "the best brain stimulant and brain clearer in the world, as every connoisseur knows".

Note: An unabridged edition of Edward Roth's translation of the two books (*Space Novels of Jules Verne*), with the original illustrations of the French edition, has been published by Dover Books of New York, price 14s.

COMPANY MEETING



THE WELLCOME FOUNDATION LIMITED

MR. MICHAEL PERRIN'S REVIEW OF THE YEAR

In his review to the Trustee-Shareholders at the Annual General Meeting of The Wellcome Foundation Limited, held at the Wellcome Building, Euston Road, London, N.W.1, on 21st December, 1960, Mr. Michael Perrin, C.B.E., Chairman of the Board of The Foundation, was able to report satisfactory advances in the sales of the Company's products and in the profits achieved alike in the home market and overseas. Direct export from the Parent Company and the activities of the Subsidiary and Associated Companies in Commonwealth and other countries were all increased and the improvement in sales was common to both human and veterinary fields.

In reviewing The Foundation's record in research and production, Mr. Perrin had this to say on the question of poliomyelitis vaccine.

"It will be remembered that, when the production of poliomyelitis vaccine of the killed, or 'Salk', variety was planned five years ago, this was integrated with the wider, and long-term, research policy at the Wellcome Research Laboratories, Beckenham, and the special effort which was devoted to this particular product was designed to help to fill the gap which then existed in the national supply. During the year, it has become increasingly clear that the Ministry of Health, with whom alone all contracts have had to be negotiated, was able to rely on a total potential output, from the combined resources of The Foundation and the other two producers in Britain, which was much in excess of probable needs.

"In these circumstances an important decision was taken during the summer when production of the Wellcome vaccine 'Polimylex' was stopped for a time in favour of large-scale development of the alternative, attenuated living virus vaccine. There is evidence for the successful use of this on a very large scale in Russia and other countries and its advantages and disadvantages are now

under active consideration in the U.K. and in the U.S.A., where there is also excess production capacity for the killed vaccine. On the scientific and medical evidence available to them, the Directors of The Foundation were satisfied in their own opinion that the future is more likely to lie with this alternative type of living vaccine once it can be proved, with conviction, to be safe.

"It is in the tradition of The Wellcome Foundation that the Company should try to take a leading position in any such development and, by using the excellent facilities and scientific experience that are now available, large batches of all three types (Sabin strains) of the attenuated living vaccine have already been prepared. Tests on this material are nearly complete so that, if and when a Government decision is taken to allow its use in the United Kingdom, the Company will be in a position to produce it against a background of its own direct experience in research and large-scale development."

Much of the work in the Research Laboratories of The Foundation during the year had been concentrated on the pharmacodynamics of hypotensive drugs, and new and even more effective compounds had already been devised but they would still need to be subjected to long and critical clinical investigation. Another field in which The Foundation had an important stake and an outstanding reputation was that of helminthology, which is, in its essentials, of common concern to human and veterinary medicine. It was thus not unnatural that additional value in the field of helminthology had come from collaboration between the Wellcome Research Laboratories and the Technical Bureau of Cooper, McDougall & Robertson Ltd., which Company was acquired by The Wellcome Foundation in the summer of 1959.

In Australia and New Zealand, Cooper, McDougall & Robertson Ltd. had strongly established Subsidiaries

and, in both countries, the decision had been taken that all relevant Burroughs Wellcome products should be distributed to veterinary surgeons through them. Considerable further benefits would accrue from the combination of the different specialised fields of interest and different ways of doing business in the many overseas territories in which both operate. It was already justifiable to assume that the action of The Wellcome Foundation in acquiring Cooper, McDougall & Robertson Ltd. would be of benefit at home as well as overseas, and the results in the first year represented a good return on the investment made.

While The Foundation could be proud of its record achievements during the year 1959-60, Mr. Perrin warned of the increasing competition being encountered both at home and abroad. This was calculated particularly to affect a Company such as The Wellcome Foundation which had always prided itself on its efforts to maintain the highest ethical levels in commercial practice. Competition was now coming increasingly from firms whose main interest and experience had, hitherto, been in the field of consumer goods and who might feel free to employ promotion methods more usually associated with such products.

Mr. Perrin also referred to the adverse climate that had developed throughout the world to the operations, and therefore to the future profitability, of the Pharmaceutical Industry. He quoted a recent article in *The Times*, "The main purpose of new drugs, whether proprietary or otherwise, is to make sick people well; and newer drugs tend to enable sick people to get well more quickly." There was, notwithstanding, unquestionably a view held by Governments and the public everywhere that, at present, this purpose is only being achieved at an unjustifiable cost to the taxpayer or to the patient and it is the responsibility of the industry to help to allay any such feeling.

How modern chemistry conserves antiquities

Among the beneficiaries from high-polymer chemistry must be counted archaeologists and museum staffs, for some of the new synthetic materials have proved much more useful in the conservation and restoration of precious antiquities than materials of natural origin

by A. E. WERNER

Department of Research Laboratory, The British Museum

THE application of the chemist's specialized knowledge to the various problems that arise in the conservation of antiquities involves, firstly, the realization of the ultimate causes for the deterioration which has occurred while the object was buried, and, secondly, the development of new, sound methods of conservation based on theoretical considerations and tested by practical experimentation carried out either on trial pieces or on objects of minor importance specially acquired for the purpose.

In the past, the methods used in the treatment of antiquities were largely of an empirical nature, and the materials, such as beeswax, natural resins and glues of animal or vegetable origin, were selected simply because, of those available, they were the only ones having the physical and chemical properties which seemed most appropriate to the work in hand. However, in the past two or three decades, advances in high-polymer chemistry have led to the development of a wide range of new synthetic materials—materials which often possess a combination of physical and chemical properties not to be found in those of natural origin. The assessment of the potential value of these synthetic materials in the development of new, more reliable methods for the repair and restoration of antiquities is an important function of a museum laboratory. The actual problems that arise are many and varied and, since it is difficult to lay down any general rules; the best approach is to take specific examples to illustrate how these new synthetic materials make it possible, not merely to improve established methods of conservation, but also to carry out restoration work which would have been very difficult, if not impos-

sible, if one had been limited to the use of materials of natural origin.

Let us consider first of all some specific problems which arise in the conservation of antiquities of an organic nature. One such outstanding problem is the development of a reliable method for the treatment of wooden objects which are excavated from a damp environment in a so-called waterlogged condition. The physical condition of such wood—in which the water content may be more than 100 per cent of the dry matter—will depend upon its degree of degradation, that is, the extent to which the cellulosic components of the cell-wall have been broken down as the result of biochemical attack. If the degradation is far advanced, the resultant wood will be quite soft, almost like cheese, and it will have very low mechanical strength.

The problem of the stabilization of wooden antiquities in such a waterlogged condition involves two factors—first, the actual removal of the large excess of water without causing serious dimensional deformation of the wood, and then the consolidation of the wood so that it may be made mechanically strong enough to be handled with safety. If the water is simply allowed to evaporate in the ordinary way, the large surface tension forces exerted on the weakened cell-walls will cause them to collapse, and the wooden objects will shrink, crack or warp. Various special techniques have been tried in the past for solving this problem, but they were found to be either unreliable, limited in scope or very slow. Recently, however, two interesting techniques based on the use of new synthetic materials have been evolved which offer definite advantages over the older methods.

The first of these, which has been

studied in the British Museum Research Laboratory, depends upon the use of the synthetic polyethyleneglycol waxes. These waxes—products of the petroleum industry—possess the characteristic physical properties of ordinary waxes, but have the unusual property of being soluble in water. They are available in a polymeric series, ranging in physical consistency from soft materials, rather like Vaseline, to hard waxes similar to the typical paraffin waxes. Experiments showed that the wax of average molecular weight 4000 (the actual material used was "Carbowax 4000", produced by the Union Carbide Chemicals Co.) was most suitable for the treatment of waterlogged wood.

Direct immersion of the wood in the molten wax was found to be unsatisfactory, and a special process, shown diagrammatically in Figure 1 (overleaf), was evolved. The wooden object is first immersed in a 12 per cent aqueous solution of Carbowax 4000 at room temperature, and over a period of weeks the temperature is slowly increased up to 60° C—slightly above the melting point of the Carbowax 4000. During this period of heating, the water in the wood slowly diffuses out and is replaced by the hydrophilic wax; at the same time the supernatant solution slowly evaporates, so that at the end of the treatment the wooden object is left lying immersed in the molten wax. It is then merely necessary to remove the object, which is now tough and stable, and wash off any excess of wax remaining on the surface. This technique is simple to carry out and achieves in one process removal of the water and consolidation of the wood. It was recently used for the successful treatment of fragile, soft, waterlogged

HOW MODERN CHEMISTRY CONSERVES ANTIQUITIES *continued*

wooden artifacts, from a site at the Kalambo Falls in Southern Rhodesia, which were considered as the only known wooden tools of the Lower Palaeolithic period and had been estimated by the radiocarbon dating method to have an age of about 53,000 years.

The second technique for the treatment of waterlogged wood was worked out in the *Historisches Museum* at Berne. In this the material used is a special melamine-formaldehyde resin which is produced by Ciba Ltd. under the trade name Arigal C. The waterlogged wooden object is first freed from any acidic decomposition products of the wood by thorough washing, and is then placed in a container filled with a 25 per cent aqueous solution of Arigal C until the wood is completely impregnated—a process which in the case of large objects may require many weeks. The necessary quantity of catalyst is then added to the solution, and the Arigal C in the wood is converted *in situ* into an insoluble resin which is deposited on the cell-walls and results in the consolidation of the wood. This stage of the process is completed in 40 hours under vacuum. This procedure has been successfully used for the treatment of numerous prehistoric wooden objects obtained from burial sites in Switzerland.

Another problem of quite a different kind arises in the conservation of archaeological material which has been excavated from a salty environment. When porous objects—for example, the earthenware tablets or potsherds called *ostraka* used in Egypt for writing purposes—lie buried in salty ground, they absorb soluble salts which present a latent cause of deterioration. Thus, if such objects are exposed to atmospheric conditions in which there are fluctuations in the relative humidity—as happens in most museums—the absorbed salts tend to be transported to the surface, where they crystallize out and obscure the surface (see Figure 2). Moreover, the process of crystallization weakens the surface layer to such an extent that there is the danger of its flaking off; in the case of *ostraka*, this would result in the loss of the actual writing. In principle, these absorbed salts can be removed by the simple process of soaking the object in water; however, owing to the fragile nature of the surface, it is essential that special precautions be taken to consolidate the

surface, otherwise there is grave risk that losses due to flaking will occur.

A new synthetic material has become available which offers advantages over materials used in the past. This is a special soluble modified nylon—produced by Imperial Chemical Industries Ltd. under the trade name "Maranyl soluble nylon polymer C 109/P"—which is applied as a 5 per cent solution in ethyl alcohol to the object before washing. The surface film which is deposited on the object has two important features which make it particularly suitable. Firstly, it is readily permeable to water, thus permitting elution of the soluble salts, and, secondly, it possesses a marked degree of flexibility so that it does not exert any undue contractile force on the frail surface layers. Many hundreds of *ostraka* have been treated by this method, and the results have been uniformly successful. Figure 3 shows the same *ostraka* as in Figure 2 after treatment.

Incidentally it was also found that the soluble nylon polymer possesses adhesive properties which make it particularly suitable in cases where it is necessary to use a mobile non-aqueous adhesive. Such a problem arose in connection with a fragment of a tempera wall painting from a tomb at Thebes of the XVIIIth dynasty, in which the paint was blistering badly and tending to flake away from the ground layer. Owing to the risk of activating soluble salts which might be present in the plaster support or of softening the ground, the use of a traditional aqueous adhesive such as gelatine was considered inadvisable. When a warm 5

per cent solution of the soluble nylon was brushed over the areas of blisters and flaked paint and gentle pressure applied, the alcoholic solution, having a relatively low surface tension, readily penetrated the fine cracks in the blisters and flowed underneath the protruding flakes of paint, drawing them back into position. In this way it was possible to form a secure bond between the re-attached paint and the ground. Another added advantage of this material was the fact that the film has a very matt appearance, so that it does not confer an aesthetically undesirable sheen on the treated areas of the painting. Many other uses have since been found for this interesting new material in conservation—for example, the consolidation of friable paint in illuminated manuscripts and friable patina on bronzes.

Another field in which new synthetic materials have found extended use in conservation is that of adhesives in general. When considering the use of adhesives in the restoration of fragile antiquities, the one single factor of prime importance is the question of the degree of shrinkage which can occur when an adhesive sets; if this is large, the contractile forces will produce strains which are liable to cause serious distortion of the bonded complex. Adhesives which set by loss of solvent (such as ordinary glue) or which set by a chemical reaction in which volatile material is released during the condensation (such as phenol-formaldehyde or urea-formaldehyde resins) all show shrinkage to a certain degree. On the other hand, adhesives based on epoxy resins represent a new type of adhesive

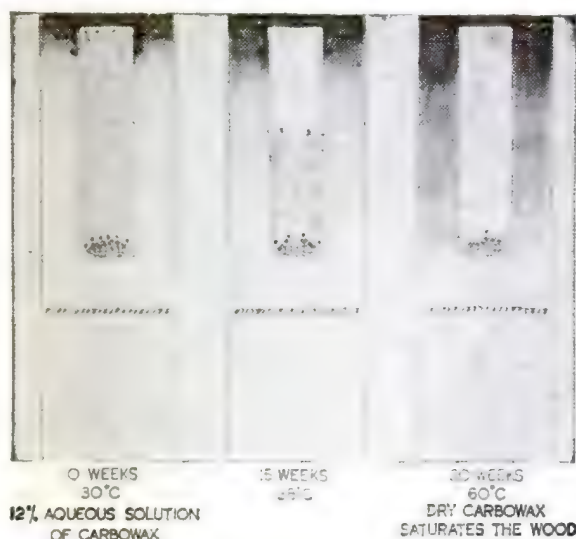


FIGURE 1. Stages in the consolidation of waterlogged wood.

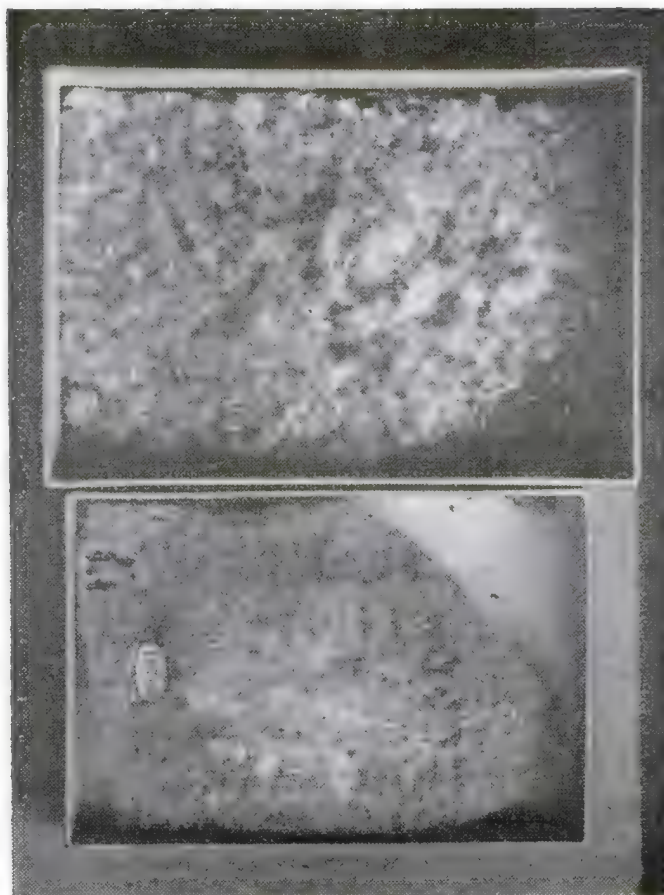


FIGURE 2. The Egyptian ostraka with massive deposits of salt crystals.

which sets by chemical reaction *without* the loss of any volatile material. For this reason these epoxy resins have found many uses as adhesives in the restoration of antiquities of all kinds.

Not only, however, are these epoxy resins useful as adhesives; their properties are such that they permit the use of improved methods for the consolidation of fragile objects. One particularly good example arose recently in connection with the consolidation of a silver hanging bowl which was one of 28 metal objects of early Christian origin discovered on the site of a church in St. Ninian's Island in the Shetlands. This hanging bowl was of particular archaeological significance because it is the only surviving example of a *silver* hanging bowl found in these islands. Its condition when received in the British Museum Research Laboratory is shown overleaf in Figure 4 (the object inside was first believed to be an internal lining to the hanging bowl, but proved to be, in fact, a separate silver bowl which, presumably, had been thrust into position when the treasure was originally hidden). The hanging bowl was a frail object, and any strength it had was due almost entirely to the layers of copper corrosion products which had been produced when the base silver alloy had mineral-

ized during its years of burial; between them the eggshell-thin brittle silver was sandwiched. It was, however, necessary to remove the incrustated corrosion layers, because they were not only unsightly, but they also gave a false impression of the original appearance of the bowl itself.

When cleaned the hanging bowl was, therefore, in an extremely fragile condition, and it was necessary to devise some form of internal support to act as a permanent reinforcement so that the bowl could be handled with safety. It was realized that a suitable material for such an internal support should have the following properties: (1) it should be colourless and transparent, (2) it should be strong but not brittle, (3) it should adhere well to the silver, (4) it should set without appreciable shrinkage so that it would be dimensionally stable, and (5) it should be easy to apply without the application of heat. The only material which best satisfied these demands was a cold-setting epoxy resin, and eventually a formulation was adopted consisting of 10 parts Araldite Casting Resin F, 1 part Hardener 951 and 1 part dibutyl phthalate. This viscous mixture was brushed uniformly over the inside of the bowl, which was rotated on a small turntable while the resin set. In this way it was possible

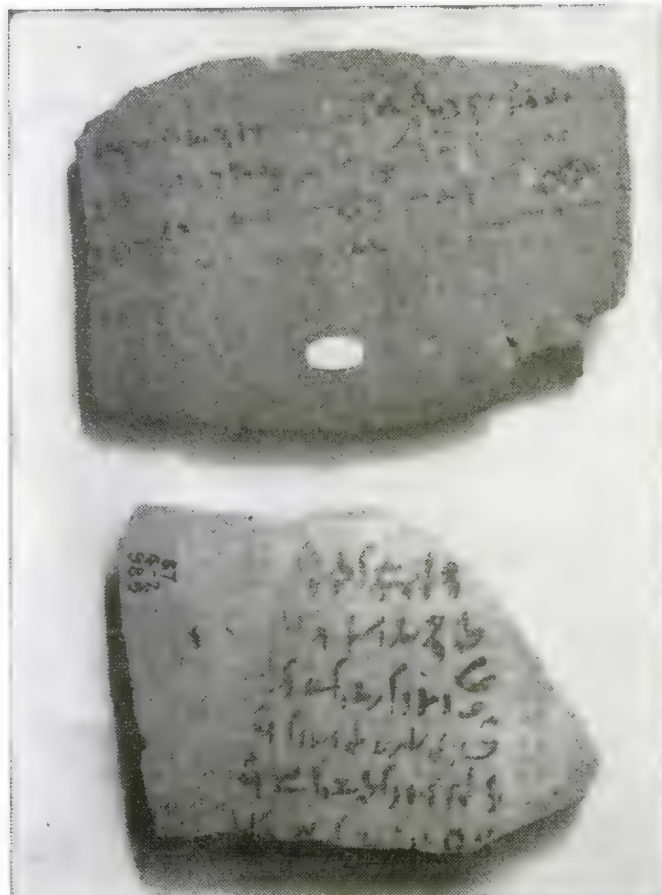


FIGURE 3. Same Egyptian ostraka after treatment to remove the salt deposits.

to build up a uniform thin layer of resin to act as a reinforcement on the inside of the bowl. At the same time the hole in the bowl was repaired by embedding many small original fragments in the resin and applying a thin coat of silver powder to the resin to make good any gaps. The appearance of the bowl after treatment is shown in Figure 5. This procedure provides a striking example of the kind of conservation which would have been extremely difficult—indeed almost impossible—if one had had to rely on the use of the old traditional materials and techniques.

Bronzes obtained from excavations are usually incrustated with corrosion products which chemical examination has shown to consist of layers of nanokite (cuprous chloride), cuprite (cuprous oxide) and malachite and azurite (basic cupric carbonates). The presence of cuprous chloride presents an acute problem from the point of view of conservation; under the influence of air and moisture—that is, under "damp" museum conditions—this cuprous chloride starts to react, leading to slow progressive corrosion of the underlying bronze, and the appearance on the surface of characteristic pale green powdery spots which are commonly referred to by museum

HOW MODERN CHEMISTRY CONSERVES ANTIQUITIES *continued*

curators as "bronze disease". Hence the main objective in conserving bronze objects should be to nullify the insidious activity of the cuprous chloride.

If it is permissible to remove the corrosion products, the problem becomes a relatively simple one, because the various layers of mineralization can be removed by suitable chemical means. The malachite is dissolved with an alkaline solution of Rochelle salt, the cuprite is removed with dilute sulphuric acid and the cuprous chloride is eliminated by cathodic reduction in alkaline solution. Finally, any residues of chlorides which may still be retained in the porous metal will have to be removed by a special form of intensive washing, in which the progress of the washing is controlled by measuring the electrical conductivity of successive baths of wash water until it reaches a minimum and the absence of chlorides is established. Such special intensive washing is essential if one is to guarantee that treated bronzes will remain stable, even if exposed to adverse humidity conditions in a museum.

However, in the case of certain bronzes, particularly Chinese, the mineralized patina has been laid down as a relatively thin smooth layer which has a pleasant aesthetic appearance and must be preserved. If "bronze disease" occurs on such bronzes, a special chemical reagent—namely, sodium sesquicarbonate—has to be employed. This reagent has no visible effect on the patina, but if the bronze is immersed in solution of this salt for a prolonged period of time, it is able to neutralize the hydrochloric acid produced when the cuprous chloride is slowly hydrolyzed: $2 \text{CuCl} + \text{H}_2\text{O} \rightleftharpoons \text{Cu}_2\text{O} + 2\text{HCl}$. Cases may also occur in which the bronze object cannot be safely immersed in an aqueous solution—for example, a bronze object inlaid with enamel work. In order to cope with an outbreak of "bronze disease" on an object of the kind, it has been necessary to develop in the British Museum Research Laboratory a special sort of dental technique. The area of active corrosion is first carefully excavated to uncover the layer of cuprous chloride, which is then covered with a layer of pure silver oxide powder. This reacts with the cuprous chloride to form a layer of silver chloride, which is impervious to moisture and seals off the corroding areas.

It has been possible to discuss in this article only a few of the problems which



FIGURE 4. Silver hanging bowl from St. Ninian's Island showing condition as received.



FIGURE 5. Inside of the silver hanging bowl after restoration and consolidation.

arise in the field of conservation. These will, however, suffice to show that a chemical understanding of the causes of deterioration of antiquities is an essential feature of the modern scientific approach to conservation, and that the

new materials resulting from recent advances in high-polymer chemistry can contribute towards the development of improved methods for the conservation and restoration of antiquities and archaeological material.

AMERICAN NEWSLETTER

A champion of the social sciences

from JOHN LEAR, our American correspondent

NEW YORK
ONE of the most encouraging events in the recent history of American science has passed almost unremarked by the newspapers here. This occasion was the establishment, early in December, of a new Division of Social Sciences within the National Science Foundation. By giving the new division equal status with three previously existing divisions, NSF recognized that study of human behaviour is as important as study of (1) mathematical, physical and engineering science, (2) biological and medical science, or (3) ways and means of maintaining an adequate supply of scientific personnel. When it is kept in mind that NSF is the national bank for support of basic research in all realms of science, the significance of this move to America's future is obvious.

There may be a temptation to read into the NSF action concern for the solution of immediate international political problems like the dilemma of the now emerging African States. Such a reading would miss the point. The immediate problems of Africa are problems that call for applied social science. The purpose NSF hopes to achieve is to prepare social scientists to prevent replications of the African troubles by digging deeper into the fundamentals of Man's history and conflicts.

It was, in fact, the increasing attention paid to applied social science by privately endowed foundations under pressure of current world affairs that prompted NSF to take up the burden of basic research in the behavioural field. The decision was a courageous one for NSF to make, for the agency's very life once depended on the question of whether social science was really safe for democracy.

In the Congressional testimony of the 1940s that gave birth to the Act creating NSF, social science was equated with change and change meant Socialism—whatever Socialism meant. In later hearings centred on the tax-exempt status of philanthropic foundations interested in behavioural experiments, the

Congressmen acted almost as badly frightened. Not until 1953, when social psychologist Harry Alpert moved into NSF from the safe and sane Budget Bureau, did social science begin to acquire a semblance of respectability. After five incredibly patient years, during which he persuaded NSF to approve psychological and anthropological studies related to experiments in the physical and biological sciences, Alpert finally won support for a few social science research projects *per se*. Then he left to become director of a new Department of Social Studies at the University of Oregon.

The man Alpert tipped to succeed himself at NSF in 1958 has now become chief of the new NSF Division of Social Sciences. As such he ranks as a full assistant to NSF director Allan Waterman. He is Dr. Henry W. Riecken, and his personal history may have considerable bearing on the growth of social science in years to come.

"Hank" Riecken was a Brooklyn boy. As far back as his memory goes, he was curious about the strengths and weaknesses of people, partly perhaps because of his father's work among the blind. In any case, he studied sociology at Harvard and Connecticut, then entered government on the research staff of the US Department of Agriculture.

It is not widely enough known that the Department of Agriculture, through its experimental stations scattered over the country, pioneered a research support system that meets the needs of modern times more fully than other systems used elsewhere in the Government. The system provides for Federal Government sharing of scientists' salaries as well as costs of laboratory apparatus, and for continuing support at annually negotiated levels over sufficiently long periods to see a man through a worthwhile basic study. Riecken will accomplish a great deal if he can manage to apply the old agricultural system to NSF support of social science.

Another significant fact that has been forgotten—if it was ever commonly appreciated—about the Department of

Agriculture is that opinion sampling on a practical scale began there. It was back in the days when Franklin Roosevelt's New Deal was revolutionizing the life of the farmer. FDR needed to know the attitudes of the rural electorate more reliably than he could learn them through local politicians, and Dr. Rensis Likert developed statistically-controlled polling in the Bureau of Agricultural Economics to a degree that provided the President with a faithful mirror.

With the coming of the second World War, other agencies of Government—the Treasury, the Office of Price Administration, the War Production Board—called for Likert surveys to guide them. As agents of a democratic people they had to estimate how much control the people would willingly, if reluctantly, accept. Could food rationing be imposed without provoking civil disobedience? Could prices be fixed with popular consent? What were reasonable production goals for this or that? How could wage earners be encouraged not only to buy war bonds but to hold them as a long-term investment? Riecken worked in Likert's polling unit for the two years 1941-43, then perfected aptitude tests for Air Force bomber crews, then successively returned to agriculture for a year, went back to Harvard for his Ph.D. taught at Harvard and Minnesota, and at last joined NSF in 1958 in the belief that here was a public service he could not refuse.

Creation of NSF's new Division of Social Sciences is an enormous compliment to Riecken's effectiveness as an administrator, one of the "New Men" C. P. Snow likes to talk about. Those who know the new Assistant Director of NSF best say the key to his personality is firmness. He has discouraged exaggerated claims by social scientists for the benefit of social science research, he has resisted the drumbeaters in Congress; at the same time, he has refused to be intimidated by the scornful, he has pressed every legitimate advantage, and he has taken care to explain the meaning of social science in terms of human values.

THE leader of the design team at Bristol which brought forward both the huge Brabazon and the Britannia airliners was 56 last May. All the signs are that Britain's first supersonic liner will be put in his lap. If that happens, he should just manage to bring it to the flying stage before the time comes for him to retire. That would make a worthy climax to a working life of more than forty years with the same company, and to a period of service which completely bridges the transition from the wooden aeroplane with its struts of wires to the metal structure, and on from the system of concentrated spar and thin skin wing construction to the modern form of box construction.

Dr. Archibald Edward Russell would be the last to claim that he invented the box system. In fact no distinguished designer has ever claimed less glory; but history is obliged to record that this form of construction came in with the Brabazon. It is also bound to conclude that without the experience gained in the Brabazon, the Britannia could not have presented itself to operators as the liner with the lowest structure weight in the world. Now Russell is about to watch fly his little experimental all-steel supersonic aeroplane which, sad to relate, has come out over weight. There, and in certain other factors which his cautious mind declines to sacrifice on the altar of optimism, lies the secret of his firm refusal at this stage to have anything to do with a Mach 3 airliner.

If Russell has his way, Britain's first supersonic liner will have a speed of something like 1,500 m.p.h. That means it will be built in the main of aluminium, which the designer already understands and has enough experience of to be sure he can produce a successful liner in it. This does not mean that Russell doubts his ability to build an entirely reliable steel structure for a speed of 2,000 m.p.h. If you tackle him on his stubborn opposition to the Mach 3 liner at this stage, you are likely to be told first that it would have a high structure weight. Heavy structure, says Russell, leads to an inefficient aeroplane. Next, he is satisfied that the steel aeroplane would cost a lot more. Finally, he may confess that he dislikes the idea of storing fuel in an aeroplane whose surface temperature is higher than the spontaneous flashpoint of that fuel. By way of clinching that point in his quiet, unemphatic way, he murmurs: "I don't know an aeroplane that has not had a leak in its fuel system at some time."

As to utility values, Russell remarks that the difference between the Mach 2 and Mach 3 liner on the Atlantic run will amount to 25 minutes. When everything is weighed up, he has not a shadow of a doubt about which kind of supersonic liner Britain should build. The soundness of his earlier work means that his opinion is treated with respect in the highest quarters. Those who remember the Brabazon only as a white elephant have failed to note the quite remarkable successes its design achieved—among them, a better lift-drag ratio than had ever been obtained before and the box system of wing construction. It was the conception, imposed from without, that was wrong and not the aeroplane that emerged from that specification.

At that time in the middle of the war, the accepted view

PROFILE Dr. A. E. Russell

A cautious approach to supersonics

was that only millionaires and film stars would fly across the Atlantic. The assumption was that they would want facilities comparable to those of the *Queen Mary*. Thus a great liner for only 50 passengers (later raised to 78), each with his own bunk, with space for a separate, spacious dining room, was commissioned. Perhaps the biggest challenge to the designer was what to do with the engines. Calculations quickly showed that the installation of the multiple piston engines—and there was no prospect of gas turbines at that time suitable for civil aircraft—would represent one-third of the total drag. The challenge was met by deciding to "suppress" the engine nacelles in the wing. That meant a big wing and led on to the adoption of box construction.

Britain was not alone in her illusion that the Atlantic airliner must ape the ways of the great ship. In the United States, the Convair and Lockheed firms were busy on similar projects. The Bristol team had introduced an innovation, using a model to check the calculated modes of vibration in the Brabazon wing, and thereby gave a valuable idea to George Shrier, of Boeing, who called in on his way back from Germany and subsequently applied the method in the design of the high aspect ratio, padded, swept-back wing. This watch on vibration frequencies was again a first introduction. It brought the study of dynamic effects into aircraft design. If anybody had whispered "fatigue" in those years, he would probably have been thought a nervous crank, but events have shown that the path to a long-life aeroplane was being laid.

When the time came for the Britannia turboprop liner to be built, it was deliberately designed for long life. Thus when, after the Comet disasters, the Britannia had to be subjected to fatigue tests in the water tank at Farnborough, it emerged without any limitation on flying hours. Theoretically it can go on flying to the end of the century, whereas the best that most liners can be allowed is a total of 30,000 hours or about ten years. The Britannia would certainly have sold in hundreds instead of scores if engine



and other troubles, unassociated with its structure, had not caused it to be two years late on the market.

Russell became chief designer as the Brabazon project started. This tale of impressive technical progress is the tale of his life, although none of his friends has ever got him to admit it. He denies none of the responsibility, but he points with characteristic modesty to the splendid material which has composed his team. Five of them now are professors. He goes further and insists that the periodical building up of the team is the secret of its success. It is, he says, on the young men coming from the university and feeding in the latest methods and systems that a design team must depend. This is not a false modesty. He does indeed trust his young men and let them get on with their jobs, but his own experience is so comprehensive and his retiring nature is so solidly proof against anything spurious that no one can expect to lead him up the garden path. Furthermore, he remains the technical enthusiast and the hard worker he was in his youth. He still arrives at his office at 8.30 in the morning.

He is of Scottish descent. His grandfather was a minister in Scotland. One uncle was chief naval architect of Denny Brothers on the Clyde; another is Sir John

Russell, the eminent agriculturist; a third was a professor of philosophy; and his father was a schoolmaster in Bristol. Young Russell always wanted to be an engineer and, after graduating at Bristol, he would have joined his uncle on the Clyde had there not been a slump in shipbuilding in the middle twenties. Instead, he joined the Bristol omnibus enterprise and then, finding after a year that a friend was leaving his post with the Bristol Aeroplane Company, Russell decided almost casually that he would try for the job.

The university recommended him, and he was put in the technical office. He started on stress work, establishing the taxi-ing and landing characteristics of the undercarriage of a new type, the Berkeley. On stressing he remained, and by the end of a year was aware of his need for more mathematics. He soaked himself in applied mathematics, agreeing, as he once said, with the scientist who held that the "approximate solution of the right problem is better than the exact solution of the wrong one". Meanwhile he had come into contact with Harold Pollard, who was leading gradually the transition from wood to metal, working to begin with on nothing more ambitious than steel tubes for fuselage frames and slowly advancing to the all-metal aeroplane. In its way, it was an apprenticeship in progressive design.

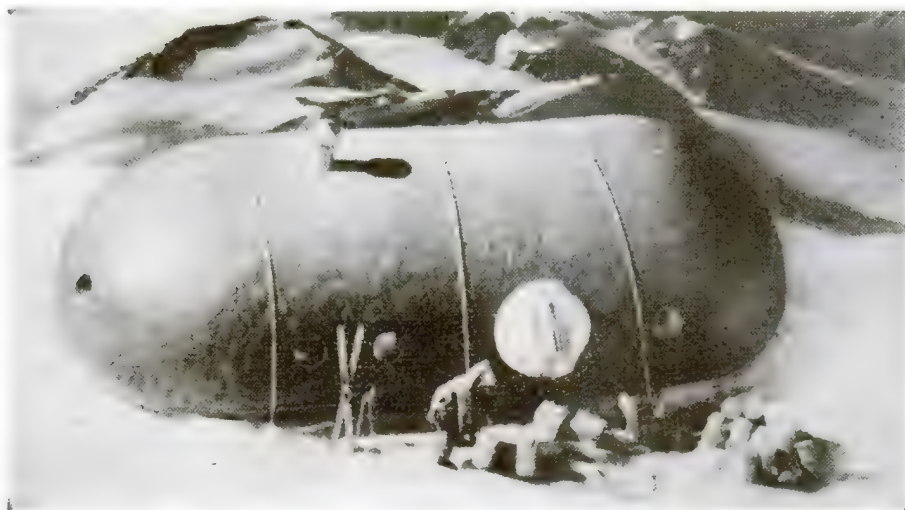
Soon Russell found himself overloaded with work. His chief had been sacked for persistent lateness in the mornings—though he made up for it by staying late at night. Nobody was appointed in his place, and for two years Russell took work home and filled his week-ends with labour. That got him his first promotion, and by the early thirties he was in charge of the technical office. He thus had a large share in the structure of Britain First, the civil aeroplane that led to the Blenheim bomber. On into the war his work was still on structures, through the Beaufighter, the Beaufort and the Brigand, until he was made chief designer in 1944. He has long been a director of the company and is now the Technical Director.

Russell has never had any taste for publicity or public appearances. When he has something useful to say, it is put on paper for the benefit of his fellow designers and technicians. Nor has he any desire for the doubtful joys of management. If he could avoid ordering people about, he would; if he could skip the administrative duties of high office, he would be happier. His interests are all technical and particularly constructive. (He created his own garden on the outskirts of Bristol out of a field.) And he is persuaded that he chose his life's work at a time when the odds against him were short. "Today", he says, "there are 2,000 technicians and designers in the British Aircraft Corporation; when I started, you only had to be good among five or six."

In his middle years, before specialization had arrived in the aircraft industry, he had of necessity to take a hand in every phase of design. That is the experience that has made him so valuable a pilot in the period of development. His skill since in advancing steadily without barking his shins accounts for his influence in the matter of Britain's supersonic liner.

Science in British Industry

Rigid foam houses



A model of a polyurethane foam building made from authentic materials.

PERMANENT rigid buildings can be erected in three hours, under conditions ranging from tropic to Antarctic, by means of apparatus and materials which could be dropped from an aircraft by parachute. The basis of the building is a flat-bottomed completely enclosed envelope made of proofed fabric (preferably nylon or Terylene) anchored to the ground or snow by nylon ropes. The envelope is inflated in four minutes by a small compressor. The pressure differential required to do this is very small—a hundredth of an atmosphere would suffice even in a 75 m.p.h. gale. An operator enters the envelope through a zip-fastened door, carrying with him a spray gun, two cans of liquid and a face mask. The liquids are aerated and sprayed on to the inside of the enclosure by means of a warm air supply to a depth of three or four inches. In about two hours the foam sets hard and the building is ready for occupation. Another inch of foam can be sprayed on to the outside of the envelope at leisure, if required, and the whole building is light enough to be tipped on its side by a hand winch to permit the spraying of the bottom.

The polyurethane foam has a density of 3 lb per cubic foot and a strength roughly comparable to that of balsa wood. It is fire-resistant, mouldproof,

resistant to acids, alkalis, mineral oils and reactive chemicals, and is an excellent thermal insulator. It can be cut with a knife or a saw to permit the fitting of doors and windows. The entire finished structure can easily be moved, even floated, to a new location at need, and is capable of withstanding high winds and considerable snow loads.

All its furnishings, dividing walls, cupboards, baths, basins, chairs, tables, bunks and ducting can likewise be made of fabric and covered with foam. The liquids from which the foam is made occupy less than a twentieth of the volume of the foam, and their cost is five shillings a pound. The foam would not be attacked by insects or fungi, and for protection against rodents it may be painted outside with a polyester resin.

Inflated balloon enclosures have been used for many years, and attempts were made during the second World War to make them rigid by spraying them with concrete. This was not successful because of the poor thermal properties of the concrete, which, besides, tended to sweat.

The new system has been developed by Mr. F. Neumark of P. Frankenstein and Sons (Manchester) Ltd., and the foam liquids are supplied by Imperial Chemical Industries. Several Government departments and public bodies have expressed interest in the idea.

Electronic signal control

BRITISH Railways are to try out a new system of signal interlocking by electronic means. Previously this kind of safety measure has been effected by mechanical locks or, more recently, by electro-magnetic relays.

Mullard Equipment Ltd., who have been awarded the contract for developing the scheme, are to install the first electronic plant at the Henley-on-Thames Western Region signal box early next summer.

The technique employs easily replaceable, solid-state circuit units which plug into sockets. They have no moving parts, thus reducing maintenance costs considerably. The units will operate over a temperature range of -20°C to $+50^{\circ}\text{C}$.

The success of this innovation will depend on whether it can compete with the very high reliability of magnetic relays. The development of a foolproof electronic system is, in fact, a complex problem in logic. As the system is designed, the failure of any component results automatically in a safe setting of the signals on every part of the track likely to be affected.

Computer ousts the template

THE cutting of steel plate for the cladding of ships' hulls is an operation that lends itself admirably to automation. The rather laborious procedure used hitherto has been to produce small-scale plans of the ship's lines, from which full-scale lines are laid down in the mould loft. Wooden templates made from the "lofted" lines have then been used, in conjunction with the steelwork drawings, to mark out the required shapes on the steel.

If a computer is used, however, the data obtained direct from the drawings and from the table of dimensions can be punched on to a paper tape. This is fed into the computer, which calculates the movements to be made by an automatic cutting machine, and the orders for the movements are recorded on magnetic tape. At the shipyard, the magnetic tape is fed into a control console which sends a train of impulses to the longitudinal and transverse motion controls of the cutting machine.

The British Oxygen Company has recently demonstrated the world's first fully automatic cutting machine. The steel plate is cut with an oxy-acetylene

SCIENCE IN BRITISH INDUSTRY *continued*

flame cutter in conjunction with a Ferranti control system. It gives an accurate edge irrespective of the shape of the cut (hitherto possible only on straight cuts) and works considerably faster than conventional cutting machines. It can cut two plates at once, each up to 40 ft long, 12 ft wide and 3 in. thick. The system enables "one-off" or multiple runs to be made with almost equal economy. The magnetic tape governs not only the movements of the cutter but all other necessary functions such as gas flow, flame ignition and nozzle height. The flame and the cut are continuously monitored and in the event of failure the machine stops.

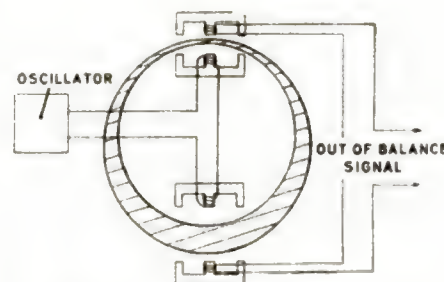
The computer-controlled cutter will improve production methods in shipyards, and will find other applications wherever profiled plate is used—for example, in structural engineering, loco-

motive building and the nuclear power industry.

Measurement of tube eccentricity

IN metal tubes which are subject to high internal pressures, any variation in the thickness of the walls may have serious consequences. Measuring probes can be pushed into the tube with corresponding jaws on the outside to reveal any change in the thickness, but this is difficult with long tubes.

A method has been devised in which two little coils serve as a transformer, using the wall of the tube as screen. With two such transformers spanning the diameter of the tube, two of the coils being inside and two outside, a balanced flow is obtained in the outer coils so long as the tube wall remains of



uniform thickness. Any marked difference in the thickness must unbalance the circuit and an output signal is recorded. Experiments showed that the system could be calibrated to give exact readings of differences in wall thickness at any point.

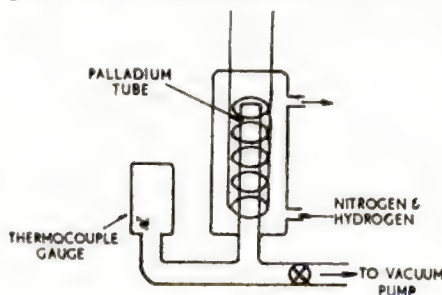
This device was developed by Mr. B. E. Nollink at the Tube Investments laboratories, Cambridge.

Science in Overseas Industry

UNITED STATES

Detecting one part in a hundred billion

USING a method based on the selective diffusion of hydrogen through solid palladium, workers at the General Electric Research Laboratory, Schenectady, have shown that it is possible to detect the presence of only ten parts per million of hydrogen in a gaseous atmosphere. Their investigations lead them to believe that it should be possible, using suitable high-vacuum techniques, to detect the presence of hydrogen even at concentrations as low as



one part per hundred billion. This is much better than can be obtained using conventional mass-spectrometer techniques, which at present are limited to concentrations of about one part per million.

The technique employed is to allow the hydrogen to diffuse through a membrane of palladium into an evacuated chamber until equilibrium is estab-

lished and the pressures of hydrogen on both sides of the membrane are equal. Determination of the pressure in the previously evacuated chamber then provides a measure of the partial pressure of hydrogen in the surrounding gas.

The diagram illustrates the general principle of the apparatus. The inside of the palladium tube is evacuated. Nitrogen or other gas is passed continuously through the outer jacket, and the temperature is raised to about 500° C. As soon as conditions are stable, the valve is closed, and after a period of about ten or twenty minutes the pressure within the tube is measured by means of a thermocouple gauge. This is equal to the partial pressure of hydrogen in the gas flowing in the outer jacket.

New route to urea

ANEW process for manufacturing urea, described at a recent meeting of the American Institute of Chemical Engineers, is designed to overcome snags that commonly plague existing processes. It promises to increase yields and lower the price of urea.

The raw materials (ammonia and carbon dioxide) react at 2,800–3,000 lb per sq. in. pressure and a temperature of 118° C to form ammonium carbamate, which in turn yields urea and water. This is the basis of all urea-making processes. The problem lies in controlling the delicate equilibrium between the reactants in order to prevent solidification. Shutdown becomes inevitable if things go wrong.

The new process applies double-stage decomposition and absorption of the reaction products, and in the final stage tilts the urea-carbamate equilibrium decisively in favour of ammonia before re-cycling, so avoiding the formation of solids. By incorporating a special pressure zone, most of the ammonia from the first absorption stage can be condensed with normal cooling water and thus directly re-cycled, without using water as a carrier. The new technique, now in operation at the urea plant of the Cooperative Farm Chemicals Association at Lawrence, Kansas, produces a 76 per cent urea solution, compared with 70 per cent obtained in other processes. For fertilizer use, the urea solution is evaporated to form solid granules, under conditions designed to keep biurea formation to a minimum, since this breakdown product of urea is toxic to plants.

Automatic thickness control

THE various systems of automatic gauge control currently used for ensuring a uniform thickness of product in modern high speed steel strip rolling mills are without question of considerable help in producing the large quantities of material of consistent quality now demanded by the automobile and other steel-using industries. In Britain automatic gauge control has been confined to cold rolling operations (*The New Scientist*, 21 April, 1960), although its application to hot rolled

SCIENCE IN OVERSEAS INDUSTRY *continued*

products is being actively pursued in the United States.

There is urgent need to consider not only the gauge control of hot strip but also the full automation of all rolling schedules. Any system of control must be dependent for its accuracy on the automatic control action of the rolling mill screwdown mechanism (the device which acts on the neck of the rolls and forces them closer together) and it is important that this should be linked directly to the actual measured gauge of the strip. Such an arrangement is technically feasible and in fact has already been put forward by the General Electric Company, Schenectady, and the Daystrom Electric Corporation, Elizabeth, NJ, as a basis for computer controlled rolling mill operation in the United States.

Containing leaks in a water-cooled reactor

A REACTOR of moderate size, to be cooled by boiling water, has just been authorized for construction in the United States. It is of interest in Britain, although no water-cooled reactor is yet projected, because of the system it embodies for containing any leak in the cooling system and restoring some of the pressure which would result from such a mishap.

Under this plan, the reactor will be contained in a pressure-tight steel vessel which is described as the dry well. Outside this dry space will be another pressure container, called the suppression chamber, which will be partly filled with water. In the event of failure in the cooling system, the leaking water will flash to steam and fill the dry well, temporarily delaying a complete fall in pressure in the cooling system, with the consequent high generation of steam which might enlarge the rupture.

At the same time, steam from the dry well will be vented to the suppression chamber, where it will condense. In a reactor of this kind some radioactive substances would be bound to escape with the coolant water, and for this reason the containment system is essential.

With gas reactors such as are at present in use in Britain, risks associated with a leak of cooling gas are extremely small. All that would leak would be carbon dioxide and this would not be heavily radioactive. Nor would the loss of the coolant cause the reactor to stop working. Gas at atmospheric pressure would still afford some measure of cooling.

Nevertheless, the technology of water cooling is being studied in Britain and is believed by some to have a useful application in future projects when its

costs can be reduced. The new reactor in the United States is to be constructed by the Pacific Gas and Electric Co. of San Francisco at Humboldt Bay, near Eureka, California. It will serve generators with a capacity of 50 MW.

ITALY

Flying saw for moving pipes

A NEW design of flying saw capable of sawing through pipes moving axially at a speed of more than 18 m.p.h. incorporates some interesting features. The saw is mounted on a carriage which moves longitudinally at the same speed as the pipe and independently of the saw driving motor. This motor is mounted in such a way on the carriage that the effect of its weight is eliminated. The whole unit has been designed to keep the weight of rotating parts down to a minimum, and hence the saw speed can be changed rapidly.

The machine consists of a welded frame on which pneumatically operated pipe-lifting equipment and the saw carriage are mounted. The saw carriage is driven by a motor through a reduction unit. The saw is traversed by a system of levers and a cam. A disc whose rotational speed varies with the speed of movement of the pipe controls the saw carriage motor speed through a system of regulating devices.

An operator at a control panel sets the machine to cut pipes into the required lengths. In one industrial application of the machine, seamless pipe is cut into lengths as it emerges from the drawing mill at a speed of about 27 ft per second. This eliminates the need for receiving tables and roller guides.

The machine has been developed by the firm of Innocenti SPA of Milan, Italy.

GERMANY

Petrol in drinking water

GRAVE concern about the danger threatening subsoil water reserves is expressed in a West German official report on the contamination of water supplies by petrol-filling stations. It has been established that the presence of one part per million of petrol in drinking water can be smelled and is sufficient to make the water unfit for drinking. Further, it can be shown that petrol is not absolutely insoluble in water. While it can be clearly seen as an oily layer on the surface when present in a ratio of one part in a

thousand, it disappears as a layer at concentrations below one part in a hundred thousand, but it can still be smelled, being dissolved in the water.

The presence of petrol in the soil inhibits grass growth and may even lead to the dying of trees. Many micro-organisms are also affected. Petrol in drinking water is not only disagreeable owing to its smell; it also contains toxic constituents, some of which can cause cancer, and certain petrols contain compounds of lead which are highly poisonous.

Adequate precautions at petrol-filling stations and oil-storage depots are therefore necessary to prevent seepage of oil into the ground.

Tough surfaces for metals

METALS and alloys may be covered with a hard, strongly anchored, homogeneous layer of titanium carbide by subjecting them, at a temperature of about 800° C, to an atmosphere containing hydrogen and a halide of boron to which a gaseous titanium halide is subsequently added. During the initial stages the boron diffuses into the metal to form an adherent film of metallic boride on to which a layer of titanium boride at least 2 microns thick can be deposited.

According to the firm of Metallgesellschaft, Frankfurt, the technique is applicable to all metals having a melting point above 780° C and capable of forming a diffusion layer with the boron. In the case of steels it is possible to couple the coating technique with the conventional heat-treatment schedule thus ensuring favourable mechanical properties as well as a hard wear-resistant surface.

FRANCE

Smooth extrusion

A LUBRICANT designed for use during the hot extrusion and plastic deformation of "difficult" materials such as nickel alloys and steel consists essentially of an anhydrous suspension of graphite and sugar in a mineral oil, vegetable oil or fat.

The new lubricant has been developed by Comptoir Lyon-Alemand, Loyot and Co., Paris. It is suggested that it should be added just before the metal engages the extrusion die and that it may be prepared simply by stirring the ingredients together as and when required.

If it proves successful in practice, this development could lead towards the more economic production of such everyday articles as window frames and lorry

SCIENCE IN OVERSEAS INDUSTRY *continued*

wheels, for efficient lubrication presents a difficult problem when attempted under the severe conditions of temperature and pressure that occur during the plastic deformation of high-melting-point metals.

Dies wear quickly because of the difficulty of making the lubricant adhere closely to the metal surface, and there is always a danger that the finished product will be scratched or dimensionally inaccurate.

Gas boosts furnace output

COKE consumption in a blast furnace has been reduced by 17 per cent—from 940 kg per tonne of cast iron to 785—as a result of using natural gas in blast furnaces as an auxiliary reducing agent. Trials have been carried out by the Compagnie des Ateliers et Forges de la Loire in its plant at Boucau close to Bayonne. The aim was to determine the behaviour of the blast furnace during the injection of the gas and to investigate the best conditions for its use.

No figures have been issued for comparative energy consumption when using coke alone and coke with gas injection, nor any estimates of relative costs. However, gas consumption was 81 cubic metres per tonne of cast iron and the daily production of the furnace rose from 163 to 186 tonnes—an increase of 14 per cent.

The trials were carried out under normal industrial conditions over a period of months. Jointly directing the programme were the Institut de Recherches de la Sidérurgie, the Direction de l'Energie et de l'Industrialisation of the Algerian Government's Délégation Generale and Gaz de France.

USSR

Optimum forging temperature

STEELS which are heated to temperatures within the range 880° C—1,040° C immediately prior to forging tend to offer a greater resistance to corrosion than they would do if they were heated to a higher temperature. Investigations carried out at the Moscow Steel Institute also indicate that, so far as corrosion resistance is concerned, heat-treatment of the steel ingots after forging is unnecessary.

Generally speaking, steel can be forged at any temperature between about 700° C and 1,250° C, therefore it is important to examine all the different properties of the finished product in

order to determine the optimum working temperature.

Evidently the texture of the surface of the forged ingot does not vary within the temperature range 700° C—1,040° C, but the tensile strength and the yield point are lowered slightly as the temperature is increased. The "percentage elongation" (or amount of permanent plastic longitudinal deformation), the notch toughness and the amount of "necking" (or reduction in area that occurs when a specimen is stretched) are all relatively unaffected by changes of temperature within this range. This work will no doubt be of interest to those metallurgists and engineers who are concerned with the future automation of the forging process.

Thermal fatigue

QUENCHING jigs, tongs that are used for handling hot metal, and the valves of internal combustion engines are but a few examples of components that are repeatedly heated and cooled, thus suffering thermal fatigue.

Recent research at the Moscow Institute of Physical Engineering indicates that if these components are made from heat-resisting steel, as is often the case, it is unwise to allow them to reach temperatures above 800° C for then the internal stresses have a detrimental effect on the mechanical properties.

Evidently the actual structural changes which occur at this temperature have only an insignificant effect on the properties, but since the component is cooled so rapidly this partial annealing is insufficient to eliminate the ill-effects of the cyclic stresses. Thermal fatigue seems to present much less of a problem with this type of material if the upper temperature is not allowed to rise much above 600° C.

AUSTRALIA

Ridding sheep of liver fluke

THE use of tetrachlorodifluorethane in the treatment of sheep infested with liver fluke has given very promising results. For more than 30 years farmers have had to use carbon tetrachloride or hexachloroethane against the liver fluke. But these drugs are not always effective against the parasite and sometimes kill the sheep.

The new drug has the great advantage of lower toxicity to the sheep, while killing almost 100 per cent of adult liver flukes. A somewhat lower effectiveness against the younger stages of the parasite was overcome by a repeat dose administered a little later.

The first reaction of the liver fluke to tetrachlorodifluorethane is to expel all the eggs lying in its uterus. The body of the fluke then begins to disintegrate from the tail upwards; the suckers sometimes remain active after the rest of its body has disappeared.

Sheep were not adversely affected by doses of the new drug as high as 1.0 g per lb body weight. This is three to six times the amount used successfully in field drenching experiments on several commercial properties in New South Wales. The new treatment costs about the same as hexachloroethane method, but is somewhat more expensive than the use of carbon tetrachloride. The research was carried out by Dr. J. C. Boray and Mr. I. G. Pearson at the McMaster Animal Health Laboratory in the University of Sydney.

Mechanizing the sugar-cane harvest

ALTHOUGH about 90 per cent of the world's sugar cane is still cut by hand, this slow and laborious method of harvesting is on the way out. In Australia, Massey-Ferguson Ltd. have devised a tractor-mounted machine that "tops and tails" the cane, chops it into one-foot lengths, and then loads it into bins carried on a trailer behind the tractor.

Operated by a team of three or four men, the machine will deal with 100 tons of cane a day if the crop is clean and upstanding. Tangled, fallen cane takes longer to salvage, and, with poor crops, output may fall to 50 tons a day. This is still an enormous advance over the 10 tons a day normally produced by four men armed only with sharp knives. Where casual labour is not only costly but rare, as in Australia, the future of mechanized harvesting of sugar cane seems assured.

In South Africa, too, mechanization is arousing considerable interest in the sugar industry. At a recent demonstration near Mount Edgecombe in Natal, a prototype harvester successfully cut cane at the colossal rate of one ton per minute, equivalent to two acres an hour on average terrain. This remarkable high-speed machine was invented by two engineers, I. A. Bell and P. R. H. Langerman and is built by the Inca Manufacturing Company, of Durban.

The harvester, which is towed by a tractor, consists of a front-mounted disc that tops the cane, and guide rails that convey the cane to the rear, where the main blade severs the cane below ground level. This blade follows the contours of the ground. Operating costs are claimed to be half the present figure. Gathering up the cut cane is a separate operation.

WHEN INSULATORS CONDUCT

With ingenuity, electric currents can be made to flow through an insulator as freely as through a vacuum. Electronic valves using this principle offer important advantages over semiconductor devices; and the processes of crystal growth may help in their manufacture

by Dr. G. T. WRIGHT

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THE basic property of insulators of holding electric charge was demonstrated as long ago as 600 bc by the electrostatic experiments of Thales of Miletus with amber and fur. More than 23 centuries then passed before Gray, in 1729, showed that electric charge is transmitted through metals and was able to attempt the first systematic division of materials into insulators and conductors. This major variation in electrical properties, between materials like glass and wax on the one hand and aluminium and copper on the other, is of basic importance in the modern utilization of electricity. However, a satisfactory explanation for the difference between insulators and conductors was not possible until barely 30 years ago, when the foundations of the modern electronic theory of solids were laid down by Sommerfeld and Bloch.

The central result of the modern theory is that, in suitable circumstances, electrons can travel freely through a space in which the electric potential rises and falls in a regular, or periodic, manner. The interior of any crystal forms a periodic potential field, because the constituent atoms of the crystal are arranged in space in a regular fashion. Consequently, and because almost all solid materials are crystalline in nature, one might imagine that electrons should be able to travel through almost all of them, and therefore that such materials should be conductors. However, because of the quantum rules which electrons must obey there are restrictions on their freedom to move through crystals; and it is these restrictions which determine whether a material is a conductor or an insulator.

One of the restrictions is that the energy of the electron must lie within certain well-defined ranges, or bands, which are characteristic of the crystal

and which form its "allowed" electron energy bands. These bands arise from the interaction of the moving electron with the atoms of the crystal; they are like lanes on which traffic must move at a specified speed or not at all. The two lowest "allowed" bands and the "forbidden" region between them are illustrated in Figure 1. The first allowed band is termed the valence band, because the electrons which occupy it come from the outer or valence levels of the constituent atoms; between this and the second allowed band is a forbidden region in which electrons cannot exist.

A further restriction is that not more than two electrons in the crystal can have the same energy. Thus an allowed energy band can hold no more than a fixed number of electrons. In practice it turns out that in metals there are more than enough states in the valence band for all the electrons. This means there are always empty states available for electrons to rise into; so that when a voltage is applied they can acquire the slight additional energy required for them to drift through the crystal and carry current. In an insulator, on the other hand, all the states in the valence band are filled. In this case there are

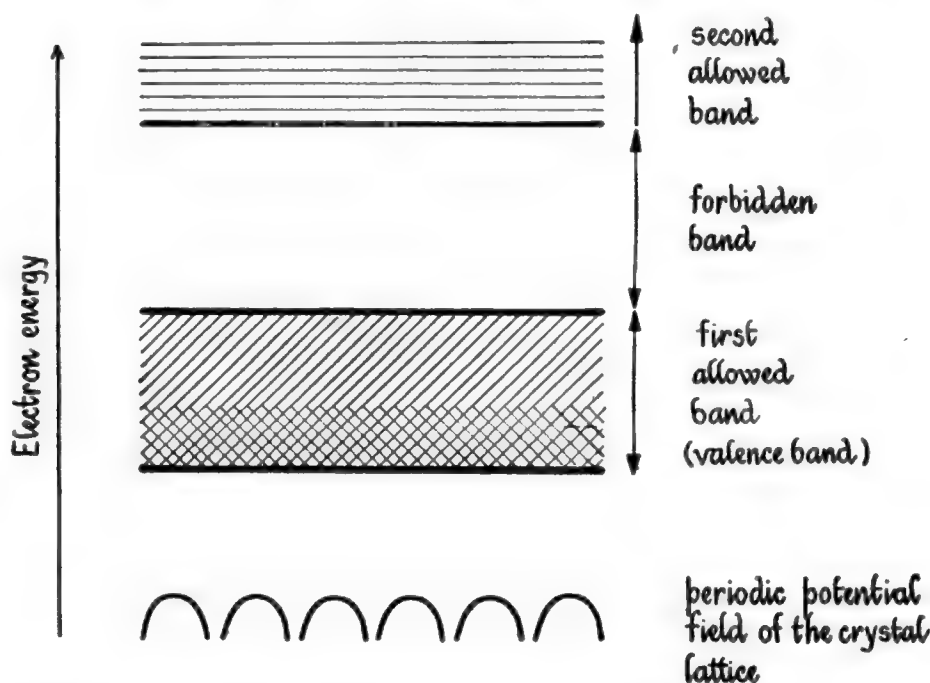


FIGURE 1. This diagram illustrates the electronic energy band structure of a crystal. When the valence band is completely filled with electrons (shown by diagonal hatching) electron movement cannot take place and the material is an insulator; when the valence band is only partially filled (shown by cross-hatching) electrons can move by using the empty levels and the material is a conductor.

no empty states available for electrons to rise into unless these can acquire enough energy to cross the forbidden band into the second allowed band; in normal circumstances this is not possible, and current is not obtained when a voltage is applied.

Now although insulators do not normally carry current it is evident that in the second allowed band there are empty states which in principle could be used for this purpose. One would anticipate that by introducing a sufficient number of electrons from an external source into these states one would obtain a "conducting insulator". The situation would be analogous to that obtaining in the thermionic vacuum diode, in which electrons are emitted from the hot cathode into the normally insulating vacuum between cathode and anode and give current when a voltage is applied; in both cases the current would be "space-charge-limited" (s.c.l.), because the number of electrons able to get into the space between cathode and anode would be limited by their own mutual charge repulsion. If these empty states could be used in this way one would have a solid state "dielectric diode" which in its electronic applications should be able to complement the vacuum diode and the semiconductor diode.

Only recently has s.c.l. current in insulators been achieved, in the author's laboratories, and observations made of the square-law dependence of current upon voltage which is characteristic of this type of current flow. To do this it was necessary to solve the two basic problems of electron injection into the crystal and electron transport through the crystal; these may be explained with the help of Figure 2, which shows the relative positions of the empty states in an insulator and the occupied states in the metal. Evidently the first difficulty occurs when it is attempted to move electrons from the metal into the insulator; at the contact there is an energy step which prevents this unless the electrons can in some way acquire extra energy at the contact. This can be provided by inserting suitable foreign atoms into the surface layers of the insulator and allowing them to become positively charged by giving up electrons to the metal. In this way a fixed electric double layer is formed by the separated positive and negative charges at the contact; by passing through this layer, electrons leaving the metal can

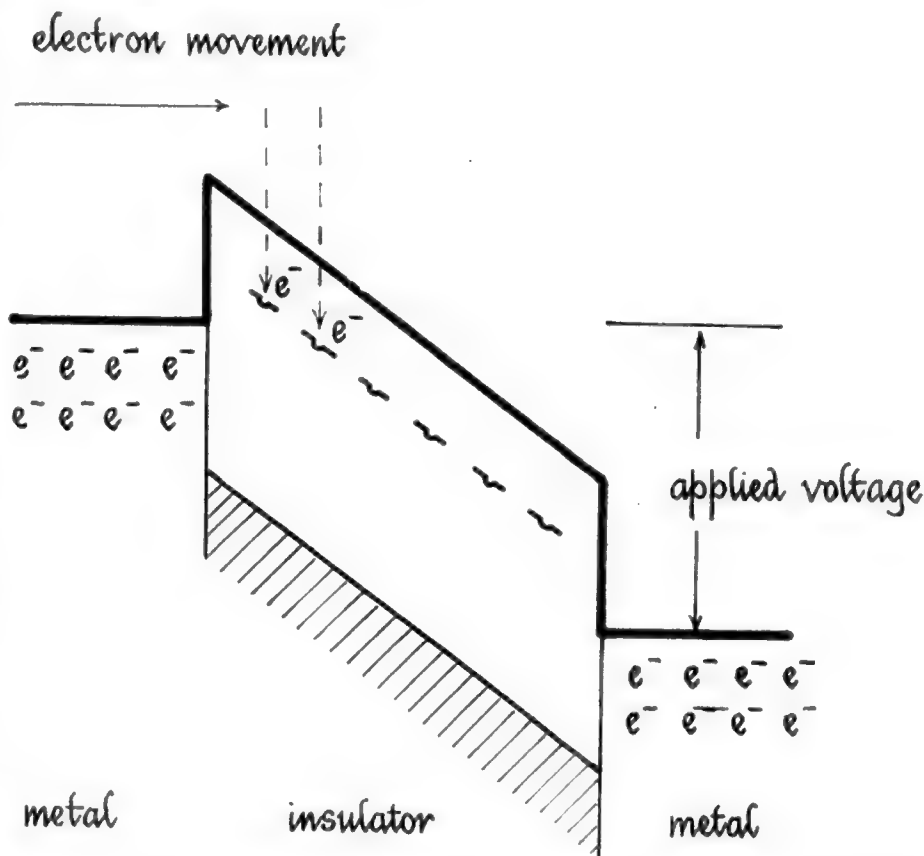


FIGURE 2. When an insulator is held between two metals and a voltage is applied very few electrons can enter the insulator because of the energy step at the contact. Those that do are soon trapped as shown and prevented from carrying current.

gain the energy they need to enter the insulator.

The second difficulty occurs when the electrons are in the insulator, and arises because it is not possible in practice to grow perfect crystals. All real crystals, in fact, contain defects and imperfections, some of which are able to act as traps for electrons and prevent them from carrying current. These defects cannot be entirely eliminated, but it is possible to compensate for them. This is done by placing in the crystal suitable foreign atoms, each of which is able to donate an electron to a trapping defect; in this way the traps are all filled, and so made ineffective for trapping electrons which are subsequently injected.

In principle these techniques for solving the problems of injection and transport can be used to obtain s.c.l. current in a wide range of materials. As yet, however, initial experiments have been made only for the particular case of cadmium sulphide. In its pure

form this is a pale yellow insulator which can be grown quite readily into transparent plate-like crystals. Cathode and anode electrodes are placed on opposite faces of the crystal and s.c.l. current is obtained when voltage is applied.

During the past few years the expansion of solid state electronics has been so considerable that it now virtually forms a new sector of electrical engineering, having ramifications in both of the traditional divisions of light and heavy engineering. This achievement of s.c.l. current in insulators has opened new opportunities for fundamental solid state research and for the development of new solid state electronic devices. To the electrical engineer it is particularly the latter prospect which is of interest. So it is necessary to try to assess whether s.c.l. current in insulators, at present an achievement of the research laboratory, is likely to be of any practical value for the development of useful devices.

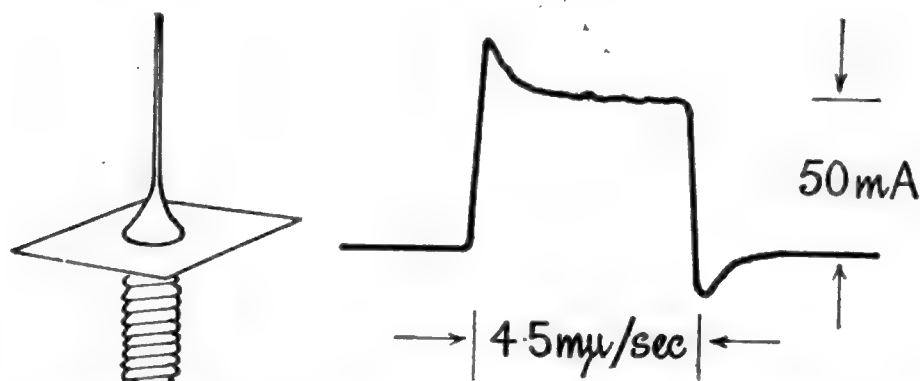
WHEN INSULATORS CONDUCT *continued*

FIGURE 3A (left). Sketch of a typical construction for an experimental dielectric diode. The cathode contact to the crystal is soldered to a 10BA screw for mounting; the anode lead is secured with conducting silver cement.

FIGURE 3B (right). Response of an experimental diode to a short voltage pulse, showing the very rapid switch-on and switch-off characteristics. Measured by A. Conning.

The s.c.l. vacuum diode, the diffusion limited semiconductor diode, and now the s.c.l. dielectric diode, are all basically similar in operation. They each possess an input electrode (cathode or emitter) and an output electrode (anode or collector) between which the current flows when a voltage is applied. When current is flowing a certain amount of electrical charge is contained between these electrodes and is continuously passing through the device; the magnitude of current depends on how rapidly this charge passes between the electrodes, because this determines how frequently the charge "stored" in the device is fed into the external circuit. Evidently to obtain a large current the input capacity of the device for storing charge must be large and the transit time of charge must be small. Now in the semiconductor diode a high density of stored charge can be obtained and a large input capacitance can therefore be obtained in a device of small physical size. In the dielectric diode, however, the mutual repulsion between the electrons which form the stored charge prevents a high charge density from being reached. Accordingly the active region in this device has to be much larger than in the semi-conductor diode in order to achieve the same value of input capacitance.

In practice, the dimensions of a s.c.l. device for high current operation, as in power rectification, would be impracticably large. However, in moderate or low power applications, as in much radio, television and communications equipment, the active region in either

device is so small that the actual size is of no consequence. On the other hand, it is easier to obtain a short transit time of charge in the dielectric diode than in the semiconductor diode, because charge is moved across the device by the direct action of the applied voltage, a fast process instead of just diffusing across, a slow process. These considerations suggest that the dielectric diode should be particularly suitable for use at high frequencies, which is the present tendency for computer and communications systems. The possibilities in this direction are indicated by Figure 3, which shows a dielectric diode switching on and then switching off, in each case in a time of the order of one-thousandth-millionth (1 mμ sec of a second).

A very useful feature of s.c.l. diodes is that the number of electrons available for carrying current is not influenced by temperature; this is in marked contrast to semiconductor diodes, in which current changes markedly with changes of temperature—a disadvantage particularly in accurate or stable equipment. The new s.c.l. devices should thus be more suitable for these types of applications. Furthermore, because temperature has little effect the dielectric diode should be able to operate over a very wide temperature range. The lower limit is set by the cessation of cathode emission when too cold; this does not occur at least down to the temperature of liquid air. The upper limit is set by the loss of insulation in the crystal and need not occur until very high temperatures are

reached. Considerable research effort is at present being directed to the development of solid state devices for high temperature applications and the dielectric diode could be one solution to this problem.

The ultimate sensitivity of any device or equipment is determined by the irregular random fluctuations of the characteristics of the device or equipment which are known as "noise". For instance, the current through a diode is not truly steady, but shows small fluctuations, because there are statistical variations in the rate at which electrons pass through the device. If the current to be detected is smaller than these fluctuations it is lost. Semiconductor devices are unsatisfactory from this point of view because the noise level is high. In the dielectric diode, on the other hand, noise should be very low indeed, because strong electric forces maintain the space-charge in place and the crystal lattice helps to smooth out the movement of each individual electron as it progresses.

If this is verified the dielectric diode should be useful for the detection and measurement of very weak signals. For example, the detection of the very weak reflected signals in radar systems can be effected readily only by the use of semiconductor point contact diodes. The high noise level of these diodes limits the sensitivity and range of the system, whereas by using the dielectric diode it should be possible to realize the full potential of the equipment. In many microwave systems where the expense and complexity of devices such as the

travelling wave tube and the solid state maser are unjustified, use of the dielectric diode would effect considerable improvement.

At the present time the potential value to electrical engineering of solid state space-charge-limited devices can only be estimated. Much more fundamental research and technological development are needed in order to verify basic theory and assess the practical value of such devices. This applies particularly to the improvement of materials such as the intermetallic compounds gallium arsenide and aluminium antimonide, more suited than cadmium sulphide to device applications. This will require much effort, but it is justified in view of the prospects of s.c.l. devices for use at high frequencies, over wide tem-

perature ranges and at low noise levels.

It is natural to inquire also whether a s.c.l. dielectric triode can be constructed as the analogue of the thermionic vacuum triode. In principle this seems possible, but when it is realized that the effective electrode spacing in solid state devices may be as small as one-thousandth of an inch it is apparent that considerable technological problems are involved in introducing a control electrode into the active regions. However, a close examination of the problem suggests that it might be possible to do this by guiding the natural processes of crystal formation.

It has been said already that real crystals always contain defects and imperfections. Some of these defects take the form of a discontinuity or break in the crystal structure along a definite

line and are termed dislocations. A particular type of dislocation is illustrated in Figure 4a; this is a screw dislocation and could be produced in a perfect crystal by applying a shearing force as shown. Now such dislocations occur naturally, and the crystal grows most rapidly along the direction of the dislocation, shown by the line XY. Thus the dislocation is itself propagated along the length of the crystal.

It might, therefore, be possible to grow flat, plate-like crystals with these dislocation lines running side by side down the interior of the crystal and parallel to the surfaces; this is illustrated in Figure 4b. A sketch of dislocation pits revealed by etching in the edge of a cadmium sulphide platelet is shown in Figure 4c; these pits mark the emergence of dislocation lines at the crystal surface and could indicate the existence of the dislocation structure shown in the previous diagram. Now at the high temperature of crystal formation impurity atoms tend to diffuse towards dislocation lines and precipitate out along them. It might be possible to use this precipitation process to produce conducting lines in the crystal and thus form a most effective control grid for modulating the flow of current from a cathode placed on one face of the crystal to an anode placed on the opposite face.

In this way one might be able to grow flat crystals with the control electrode incorporated and so provide an elegant solution to the problem of how to make an amplifying dielectric triode.

At present this suggestion is little more than a flight of fancy, although one hopes that it will eventually be feasible and practicable. However, since it appears that the triode should be able to operate at frequencies higher than the transistor, have a lower noise level than this device and be little affected by temperature changes, there is encouragement for pursuing the problems involved in its development. This is particularly so since these are predominantly fundamental in nature and their investigation will provide much basic information about the physics of the solid state. The existing achievements of solid state electronics go a long way towards justifying the opinion that in this sector of electrical engineering the ultimate limits of technological progress will be set only by the fundamental laws of nature, and that any device which is theoretically possible will in the long run become a practical proposition.

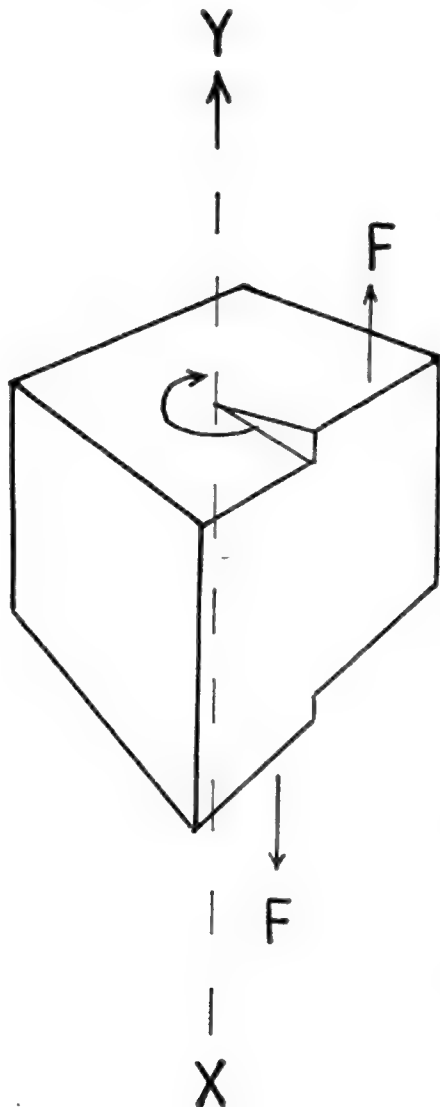


FIGURE 4A (left). Screw dislocation formed in a crystal by applying a shear force FF . Atoms condense on the exposed edge which "winds up" as indicated so that the crystal grows in the direction XY .

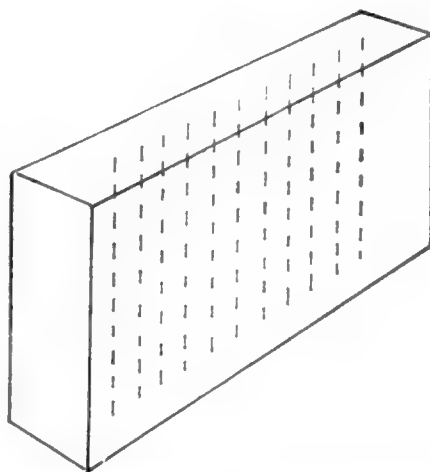


FIGURE 4B. Idealized dislocation pattern in a crystal lamina.



FIGURE 4C. Sketch of etch pits in the edge of a cadmium sulphide crystal showing the points of emergence of dislocation lines. Crystal etched by P. Langlois.

Materials for the Future—6

PYROCERAM

The discovery of these glass-ceramics grew from unexpected observations during the production of photosensitive glasses. Their uses already range from domestic ware to missile equipment and their unique properties promise an immense variety of other applications

by Dr. CHARLES H. GREENE

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A WHOLE new class of materials which can be shaped by all the versatile processes used for ordinary glass, but which have new and unique properties, has come recently from the research laboratories of the Corning Glass Works in the United States. These glass-ceramic materials, which are designated by the Corning trade-mark "Pyroceram", are manufactured by the controlled crystallization of a wide variety of glass compositions. Although a bare beginning has been made in developing the potentialities of these materials, such articles as missile radomes, cooking utensils, printed circuit boards, mirrors for space telescopes, thermal setting cements and high-temperature bearings are being produced from them.

In this article we shall consider first the chemistry of these materials and the process by which they are produced. Then the history of how they grew out of the photosensitive glasses, another fantastic Corning discovery, will be reviewed briefly. Finally some of the remarkable properties which can be obtained by controlled crystallization of glass will be discussed in connection with some vistas of future uses for Pyroceram.

The Pyroceram process depends upon the fact that glass, at ordinary temperatures, is an undercooled liquid which is in an unstable state and can be made to crystallize by heating to the proper temperature with crystal seed or nuclei present. By such crystallization glass is converted to a dense mass of very tiny interlocking crystals, which is generally opaque and which has new and valuable properties quite different from those of the original glass.

Accidental or uncontrolled crystallization, which sometimes occurs during

the manufacture of ordinary glass, produces only a few coarse crystals and is highly undesirable. The secret of obtaining good results is to add to the glass in its original formulation a nucleating agent which will initiate the growth of billions of fine uniform crystals in each cubic millimetre of the glass when it is given suitable heat treatment. The Corning patent covering the material and the process reveals that titanium dioxide is an effective nucleating agent for the crystallization of a wide variety of glasses.

The next step in developing a glass-ceramic is to select a crystalline inorganic compound which has desirable properties and which can be melted to a glass. The latter requirement usually results in the selection of a silicate. Small amounts of other materials may be added to the batch, either to facilitate melting or to prevent accidental spontaneous crystallization, but the major part of the glass which is to become a Pyroceram must have the composition of the desired crystals.

For example spodumene, which is a crystalline compound of the oxides of lithium, aluminum and silicon, has a very low coefficient of thermal expansion. This makes it a desirable material for ceramic objects which must resist sudden changes in temperature. Thus, to make Pyroceram cooking ware, raw materials which will yield lithium, aluminum and silicon oxides in the proportions to form spodumene may be mixed with the proper amount of titanium dioxide as a nucleating agent and with other minor constituents, and melted to form a homogeneous liquid glass. For these glass-ceramics it is vital that the starting glass be unusually homogeneous, with quality like optical glass.

The liquid glass is cooled and shaped by conventional glass-forming processes. Thus for cooking skillets, lumps or, in glass parlance, gobs of plastic glass are pressed in steel moulds. Saucepans are shaped by blowing bubbles of glass in rotating moulds. The pieces are annealed and handled with all the care needed for ordinary glass, since at this stage they are transparent and vulnerable to scratches and bruises like conventional glasses. Any defects in the interior of the glass may be seen and rejected by inspectors at this stage in the process.

Next the ware is heated to a temperature where nuclei are formed from the dissolved titanium dioxide. This happens at a temperature a little above the annealing point where the glass shows the first signs of softening. After myriads of nuclei have been formed in this way, the glass is slowly heated to higher temperatures where tiny spodumene crystals grow on the nuclei, converting the transparent glass to an opaque white mass composed chiefly of spodumene crystals. This is one variety of the glass-ceramic known as Pyroceram.

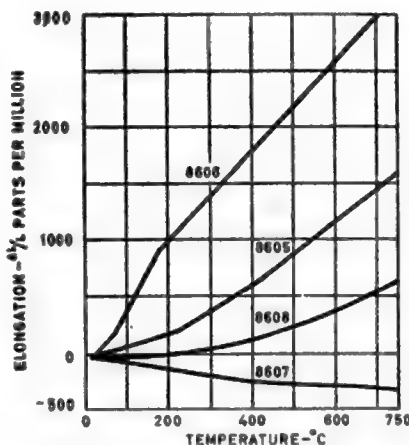
The changes in properties brought about by this controlled crystallization are dramatic. The thermal expansion drops almost to zero. This means that the ware is no longer vulnerable to sudden temperature changes, but may be heated or cooled as rapidly as is desired without any danger of breaking. Pieces at a red heat may be plunged into ice water without cracking. The value of this property in cooking ware is obvious. A cold dish of food may be taken from a refrigerator and put over a hot burner without danger of breaking. There is also a remarkable increase in strength which is desirable for this and other

uses. The surface is extremely hard and completely non-porous, so that it is easily cleaned and resists scratching very well.

Pyroceram grew from the photo-sensitive series of glasses, which had a history stretching back twenty years in the Corning laboratories. Dr. S. D. Stookey, the scientist who was chiefly responsible for the development, recounts the story in an article in *Research Management Magazine*, pages 155 to 163, 1958.

In 1937 Dr. R. H. Dalton of Corning found that the red colour produced by the heat treatment of a reduced copper glass is more intense where the glass has been previously exposed to ultra-violet light. Stookey picked up this investigation, and after several years of experimentation succeeded in producing useful and practical photosensitive glasses.

The first photosensitive glasses contained the ions of a metal such as copper, silver or gold, with cerium oxide added as an optical sensitizer. When they are exposed to ultra-violet light a change takes place in these glasses, forming a latent image which is invisible until the glass is heated. Such heating "develops" the latent image by causing the precipitation of tiny particles of metal forming a visible image. The glass containing gold is best suited for photographic purposes. By placing a sheet of such glass under a photographic negative and exposing to ultra-violet and then "developing" the image by a suit-



Thermal expansion of Pyroceram materials.

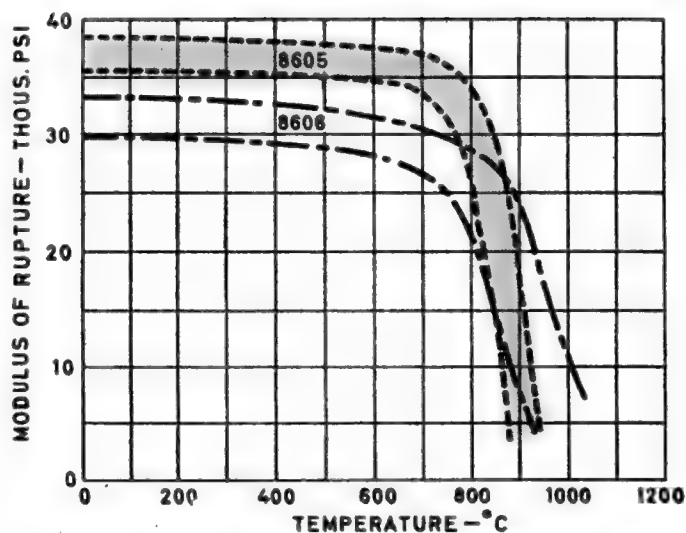
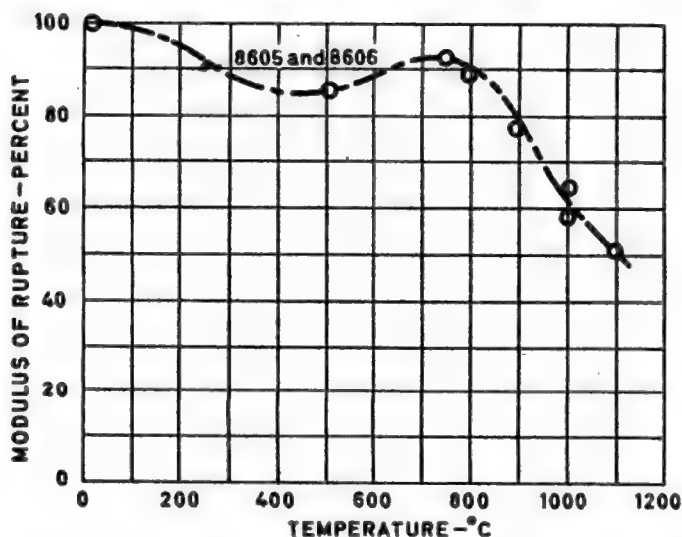
able heat treatment, a beautiful and permanent picture could be obtained composed of colloidal gold embedded in crystal glass.

Next it was found that these metal particles could serve as nuclei to control the crystallization of lithium silicate glasses, producing an opaque white opal. However, a less expensive sodium fluoride opal could also be controlled by silver or gold particles, so it was selected for commercial development rather than the lithium glass. In this process white, opaque areas could be produced in a sheet of transparent glass by exposing the desired areas to ultra-violet light, heating to precipitate the metal particles, and then heating again

to a somewhat higher temperature to grow the sodium fluoride crystals on the metal nuclei.

Studying the properties of the crystallized lithium silicate glass, Stookey found a surprising difference in chemical solubility between it and the original glass. The white opaque portions of a piece which had been nucleated with metal particles and crystallized dissolved many times faster than adjacent clear areas which had been shielded from the ultra-violet light. This made chemical machining of glass into complex and delicate shapes possible at a relatively low cost. One market for products of this sort, for example, is in fine mesh screens, some having as many as a million holes per square inch, for electronic devices. This development is known as "Fotoform" glass.

A fortunate accident brought about the next step in the invention of Pyroceram. The controller of a furnace in which a piece of Fotoform glass was being heated overnight stuck, so that the temperature became 300° C hotter than had been planned. It was expected that the sample would be melted to a pool of glass on the bottom of the furnace. Instead, when the furnace was opened in the morning, a piece of crystalline material was found which was much stronger and harder than the original glass. This material can be shaped in the same way as the Fotoform glass, and is even more useful because of its greater hardness and strength. It is known as "Fotoceram" and is used



LEFT. Modulus of rupture versus temperature. Flexure tests made at temperature indicated after equalization of specimens.

RIGHT. Effect of continued high temperature on flexure strength. Specimens held at temperature indicated for 100 hours under tensile loading of 1,000 psi then tested at room temperature.

PYROCERAM *continued*

Corning Ware percolator, cooking utensils and Pyrocera guided missile radome.

for such things as electrical circuit boards, which are shaped and perforated by the photographic process.

From the Fotoceram process it became obvious that controlled crystallization in glass is both feasible and useful. This led to careful study of the crystallization process and to search for other nucleating agents than the colloidal metal particles. Thus the Pyrocera materials which do not involve photosensitivity were discovered.

The properties of these glass-ceramics can be varied over a wide range by altering the composition of the glass which determines what crystals will be formed, and by altering the concentration of nucleating agent and the time and temperature of heat treatment which determine the size of crystals and the extent of crystallization. Hundreds of glass compositions have been melted and crystallized in exploring the field.

The coefficient of thermal expansion can be varied from negative values to over 200×10^{-7} per degree Centigrade. Low values, near zero, result in spectacular resistance to heat shock, while larger values are useful when it is desired to seal a glass-ceramic to a particular metal or conventional ceramic.

Generally the glass-ceramics are white

and opaque, but by suitable control of the crystal composition and size they may be made transparent or coloured. The surfaces are smooth and glossy and extremely wear-resistant. Because of the non-porous fine-grained microstructure they wear smoothly and uniformly, maintaining a polished surface. This makes them promising for applications in high temperature bearings where even the best oxidation-resistant metals give trouble by seizing or galling. The crystalline structure results in the strength and rigidity being maintained to much higher temperatures than with conventional glasses.

The mechanical strength of Pyrocera is many times that of ordinary glass and ceramics. It is also much less sensitive to scratches and abrasions than is the strength of ordinary glass. Flexural strengths up to 35,000 psi are available in materials now on the market, but active research in this field gives promise of still stronger materials to come in the future. As has been indicated, useful strength is maintained at temperatures where ordinary glasses soften and flow.

These properties lead to the consideration of Pyrocera materials for a broad variety of applications including such

things as brake shoes, architectural curtain walls, high-temperature ball bearings, stove and furnace parts, godet wheels, pump parts, thread guides and even piston heads for internal combustion engines. The very hard, wear-resistant character of Pyrocera materials combined with a low coefficient of thermal expansion suggests use in precision gauges.

These glass-ceramic materials can be made with unusually good electrical properties. The insulation value is excellent, and is well maintained even at elevated temperatures. High frequency losses in these materials can also be made very low, so that they are suitable for radomes and other shapes requiring transmission of short radar waves. Taken in connection with the excellent resistance to thermal shock and maintenance of high strength at high temperatures, these good electrical properties have led to extensive application in the field of nose cones for high-speed missiles. The possibility of high-precision finishing by grinding has made this application quite practical.

All in all, Pyrocera is indeed one of the materials of the future, versatile, abundant and reliable for hundreds of uses.

IT SEEMS TO ME

by GEMINUS

THE railways have had it coming to them, as the saying goes, for nearly a decade. Debts which were only a few years ago the lifeblood of the country's transport system—to tell from the statements by which they were justified in Parliamentary debates—are written off because an attempt to pay them would drive all the potential customers on to the roads. The organisation of the railways is to be changed because the old system didn't work, not because there is any particular reason for thinking that the new one will work any better. And though it may seem that the explosion of transformers in Scotland and the bumping of bogies in Essex are but ironical and gratuitous accidents, in fact even these humiliations were predictable.

For the amount of research carried out by the railways, which might have been expected to lead to better engineering design has been, in fact, pitifully small. The section of the research laboratory at Rugby concerned with these problems was being run on the man-and-boy principle (except that there were three men when I was there last).

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AS it turns out, the Medical Research Council's report on the hazards of radiation deals only inadequately with the issue I raised here a few weeks ago—that of the sense in which terms like "maximum permissible dose" and the like should be used in modern times. In one paragraph, it is true, the report does recognize that the exact doses of radiation of particular kinds which should be considered as acceptable in particular circumstances should be determined by trying to balance the biological risks of the use of radiation against the corresponding advantages. Regrettably, however, the report goes on to put forward as "maximum permissible doses" particular figures which are not calculated according to its own principles but, rather, produced like rabbits out of a hat.

Thus it is said that the level of contamination of human bones by strontium from fallout should not be allowed to exceed the "maximum permissible" level of 67 strontium units. This figure is derived with perfect propriety from the recommendations of the International Commission on Radiological Protection. Unfortunately, however, the ICRP cal-

culations involve no attempt to balance out the risks of fallout against the advantages of having nuclear test explosions.

I should say that I do not quarrel at all with the implication in the report that past fallout can only have caused a very small amount of damage, and that the figures now put forward as standards to guide the practice of radiation usage are likely to prove valuable and cautious.

My point is merely that the manner in which the MRC has put them forward does not make it plain that in all these issues risks have to be balanced against advantages, that in this process there is considerable room for argument, and that in any case it is not for the MRC but the public (presumably acting through the House of Commons) to say just how the balance should be struck.

★

THE first scientific meeting of the British Biophysical Society—a great success by all accounts—was held in physical circumstances which are in themselves a disgrace and a poignant reminder that the investment of money in the universities has not yet gone nearly far enough to take care of essential academic needs even in the most clamant fields of research.

The circumstances which so offended me are those of the large lecture hall at King's College, London, in which most of the scientific discussions took place. I would not, however, draw attention to this if I had reason to think that it was an isolated example of absurdity and discomfort.

The lecture hall can seat roughly 300 people, who are disposed on narrow semicircular benches rising up in a tier as in a Roman theatre, but more steeply. Acoustically the room is a patchy combination of reverberator and sound absorber. From the back (or top) of the hall it is not possible to see very much more than whether the lecturer is going bald or not. In front of every bench is a high plank of wood, between seven and eight inches wide, inclined at an angle too steep to hold a pencil or even a notebook, and too far away from the seat to form a comfortable resting place for sleepy heads.

The survival of rooms like these may serve as a reminder that even redbrick university education has roots in the

past, but this is a fact which can be gleaned convincingly from books. It is especially ironical that one of them should have held a meeting of biophysicists, for it is at present a fact that the two largest schools of biophysical research in the United Kingdom are housed in absurdly cramped conditions.

In the New Year some enterprising people in the Department of Education at Manchester University are holding a conference on the design of lecture theatres which should be a valuable incentive to the improvement of self-conscious design in this field.

★

IT is common to reflect with pride on the inventiveness of inventors and the enterprise of entrepreneurs, thus creating a pleasant sense that the interests of ordinary people are perpetually taken care of by the great organizations of commerce. The fallacy of this belief in the paternalism of industry can be shown up easily by means of an attempt to buy anywhere in Britain some kind of a device for holding up a Christmas tree.

This year my family cried out for a tree that would reach from floor to ceiling, which is easy enough. However, it was plain that the old-fashioned method of trimming away the lower branches and packing the bared trunk into a large box would badly impair its appearance. So it was natural to look for some more sophisticated way of doing the job. Presumably, the argument went, this problem has occurred before and someone must make something which serves the purpose.

Alas, nothing could be further from the truth. Most of the large London shops at which I inquired said they had never heard of such a thing. Many of them took leave to question the wisdom (or the sanity) of people who wanted such a big Christmas tree.

The outcome of this tragic tale is the predictable one. The tree is supported on a home-made framework of wooden joists lashed about with wire. It rocks a little, but not dangerously. I have a mark on my knuckles to remind me of the year I made a stand for a Christmas tree. Next year we shall have a small one. I shall never again rely on the all-providing reputation of the businessmen.

TRENDS AND DISCOVERIES

Easy way to gauge X-ray doses

THE blackening of photographic film, which appears after normal processing, has long been used as a method of monitoring small quantities of X-radiation from a fraction of a roentgen up to a few tens of roentgens. But it has recently been realized that massive doses of X-radiation will produce blackening of films, directly visible without the necessity of processing. W. L. McLaughlin of the National Bureau of Standards has made a thorough study of the phenomenon (*Radiation Research*, Vol. 13, p. 594) following some earlier results of H. F. Nitka and D. P. Jones (*Nucleonics*, Vol. 15, No. 10, p. 123).

In the normal photographic process, small quantities of radiation produce an instability in the silver salt of the emulsion. Developing the film transforms these into grains of silver large enough to be seen by eye. Massive doses of

radiation, however, will themselves convert the instability, or "latent image", in the emulsion into visible deposits of silver which can be measured directly. McLaughlin shows that ordinary X-ray film can conveniently be used to measure doses between 20,000 and 100 million roentgens, independently of the rate at which the dose is delivered.

The density of blackening, which is stable over several months if the film is kept in the dark, is measured in a dark room and registers the dose with an accuracy of about 5 per cent. Unfortunately, the degree of blackening is dependent on the amount of radiation energy if this is less than 300 kilovolts. For energies greater than this, however, the method is very convenient as a routine check on the large doses of X-rays given in such processes as food sterilization.

Are brains one-sided?

EXPERIMENTAL psychologists usually have great difficulty in finding dependable correlations between a patient's mental condition and any physiological abnormalities which he may show. In a recent paper (*Nature*, Vol. 188, p. 962) three scientists from the National Institute of Mental Health, Maryland, present their findings as a result of measuring the cerebral oxygen uptake in a number of old people.

I. Feinberg, M. H. Lane and N. A. Lassen gave intelligence tests to nine patients suffering from senile dementia and to five aged normal men. They compared the numerical results of these tests with determinations of the oxygen

uptake from samples of jugular blood which they took from each person from the right and left sides simultaneously. There was a substantially higher correlation, for each kind of mental test, with the oxygen uptake on the left-hand side than with that on the right-hand side, suggesting that the former has a greater significance in mental processes.

The authors tentatively indicate that one interpretation of these results is that the oxygen uptake may be a reflection of a different cerebral metabolism in the right and left hemispheres of the brain, one side being thus dominant. However, the correlation may only concern a part of one hemisphere and the present study is not conclusive.

Pulsing artery may start gastric ulcers

DESPITE a large volume of research, knowledge of the origins of gastric ulcers remains meagre. The considerable number of alternative theories which has been put forward merely illustrates the extent of ignorance in this field. A new approach has now been suggested by workers at the University of Minnesota (*Proceedings of the Society for Experimental Biology and Medicine*, Vol. 104, p. 341). They pointed out that an intermittent jet of gastric juice, taken from duodenal ulcer patients, would regularly produce ulceration in the rabbit's duodenum, whereas a constant

flow at the same pressure caused little injury. This led them to wonder whether the pulsations which pump blood through the aorta might eventually have a deleterious effect on the mucous membrane of the stomach in this vicinity.

To test the hypothesis they operated on dogs, stitching a portion of the stomach in close proximity to the aorta. Nine out of 12 developed ulceration at the part subjected to the thrust of the aortic pulsations. The prone position might therefore accelerate healing in gastric ulcer patients, for in this posture the stomach falls away from the aorta.

Pulsing reactors for biomedical research

A NEW trend in biomedical research is the use of pulsing atomic reactors to study the effects of nuclear radiation. The new Armed Forces Radiobiology Research Institute, Maryland, has ordered one of these reactors from the General Dynamics Corporation of America, which may be operating late next year.

The device will supply controlled, split-second pulses of intense neutrons and gamma rays for experiments to find out the extent of biological damage resulting from varying doses and rates of exposure to radiation. Scientists will also use the reactor to study new radiotherapy techniques, nuclear shielding requirements etc.

The peak power obtainable from the reactor, known as the TRIGA Mark-F, will be about two million kilowatts, and it will be able to operate steadily with a power output of a hundred kilowatts. It will produce both high and low energy neutrons for testing various substances.

Two-way proteins in pregnant monkeys

MEDICAL scientists have always supposed that the circulation of protein between a mother and her foetus is one way, namely from mother to foetus. Previous experiments showed the passage of antibodies, which are carried by blood proteins, from mother to foetus, and also detected in the foetus albumin and globulin, labelled with radioactive iodine, which had been given to the mother. Now Drs. Bangham, Hobbs and Tees, of the National Institute of Medical Research, have shown (*Lancet*, No. 7161, p. 1173) that in monkeys, at any rate, proteins can pass from the foetus to the mother and there is a constant interchange between the two.

They demonstrated this by operating on pregnant monkeys. They opened the uterus surgically, and injected into a vein, or the peritoneal cavity of the foetus monkey, foetal serum labelled with radioactive iodine. The uterus was then closed. Eighteen hours later the maternal blood had radioactive albumin and γ -globulin fractions. The experiment proved incidentally that it is possible to open the uterus and operate on the foetus without interrupting a mid-term pregnancy, or prejudicing the birth of a normal monkey.

TRENDS AND DISCOVERIES *continued***How many more new elements?**

UP to the present scientists have been able to recognize ten artificially produced elements beyond the 92 which occur naturally. Although these elements are detectable it is not possible to isolate all of them.

Two years ago, physicists at the Lawrence Radiation Laboratory, University of California, contrived to isolate the ninety-seventh and ninety-eighth elements, berkelium and californium respectively. One of the two scientists responsible for the achievement, B. B. Cunningham, together with J. C. Wallmann, has now succeeded in making the first identifiable compounds of californium. They produced the pure trichloride, oxychloride and oxide of the metal, all, however, in such extremely small quantities (about a ten millionth of a gram) that the determination of their composition required the perfecting of new chemical techniques.

Dr. G. T. Seaborg, Chancellor of the University of California, in announcing this advance also remarked that the ninety-ninth element, einsteinium, may be separated early in the new year. It will be the outcome of a neutron irradiation programme now going on at the Materials Testing Reactor at Arco, Idaho, which will make about a ten millionth of a gram of the metal. As the heavier elements have increasingly shorter radioactive half lives, einsteinium will probably be the last of the transuranium elements to be made in visible amounts. In this case the isotope einsteinium-254 is the element's longest-lived one with a half life of 480 days.

Although A. Ghiorso and his colleagues, at the same laboratory, are now trying to discover element number 103, by bombarding californium with boron nuclei, the high instabilities of further elements makes it unlikely that more than half-a-dozen extra ones will be found. Element 108, for instance, may have a longest-lived isotope with a half life of only a tenth of a second.

Queen ants retard larvae

IN ants of the genus *Myrmica*, if a queen is present among a group of workers rearing young larvae, the workers begin to feed the larvae earlier in their development, and feed them more regularly. Despite this, however, these larvae become prepupae earlier, and eventually form smaller pupae (M. V. Brian and C. A. H. Carr, *Journal of Insect Physiology*, Vol. 5, p. 81). This happens to both male and female larvae, and occurs gradually throughout their development. The size of the effect varies with different queens, but increasing

their number in a group makes no further difference. The actual presence of the queen was necessary, so that larvae reared in a queenless group, by workers which had previously tended larvae with a queen, remained unaffected.

The effect cannot be stimulated by competition between the queen and the larvae for food, nor by increased competition between the larvae arising because more of them survive, since it continues to operate when the surviving proportion is small. Dr. Brian suggests that the queen may either smear the larvae with some mild repellent so that the workers never settle down to give them a substantial feed, or else incorporate some growth suppressor into the food. This means that the larger larvae, which are given more food, would nevertheless grow less. Alternatively, the mere presence of the queen may increase the general activity of the workers which then disturb and stimulate the larvae more often. The increased exercise results in less of the larval food being available for body-building.

New substance sifts big molecules

SEPHADEX is a material developed recently at Uppsala, Sweden, which promises to be of great help to the biochemist. Basically it consists of granules of cross-linked polysaccharide dextran, the degree of cross-linkage determining the porosity of the material.

In biochemical applications the compound acts as a molecular sieve. It excludes molecules above a certain molecular weight, but is porous to molecules below this critical weight. For example, it is possible to separate compounds such as DNA, RNA, or protein, from mixtures with simpler substances such as salts, alcohol or impurities.

Another application of sephadex is in concentrating solutions of high molecular weight compounds which are labile and may be destroyed by heat or chemical treatment. If the dilute solution is stirred with dry sephadex, the granules take up water and low molecular weight compounds, thus causing a residual concentration of the high molecular weight compound to which they are not permeable. The use of sephadex for this purpose is described by P. Flodin and others (*Nature*, Vol. 188, p. 493). These workers have used the method in the preparation of a variety of enzymes, the mild conditions which are thus made possible being especially favourable when dealing with compounds which easily lose their activity under adverse conditions.

How to spot a chicken virus

AVIAN leucosis, or visceral lymphomatosis, is a lethal tumour disease of poultry and causes about 20 per cent losses in the broiler industry in the USA. The disease results from a virus which is antigenically related to other tumour viruses of domestic birds, such as Rous sarcoma, erythroblastosis and myeloblastosis (*New Scientist*, Vol. 8, p. 23). The study of visceral lymphomatosis (VL) has been encumbered by its long incubation period (it takes about ten months from infection to production of a discernible tumour), as well as by the fact that most of the commercial birds are congenitally affected by the disease. Many experiments required special isolated breeds of chicken.

In the last few years several reports have indicated that the VL virus could grow in, and destroy, the cells of a chick embryo tissue culture within a few days. This looked like a useful research tool. Unfortunately, however, it was discovered earlier this year that another virus actually caused the destruction of these cells. This was only a "fellow-traveller" adenovirus—a normal resident of the intestinal tract, and some visceral organs, of the chicken during the first weeks of its life—not the genuine tumour virus (*Journal of the National Cancer Institute*, Vol. 29, p. 1443).

Now, from a laboratory in California (H. Rubin, *Proceedings of the National Academy of Science*, Vol. 46, p. 1105) comes a report suggesting that a practical method for the detection and measurement of the VL virus may be available. Rubin found that tissue cultures prepared from some samples of pooled chick embryos were resistant to infection with Rous sarcoma virus (RSV). This resistance was associated with the presence of one or more embryos which, when cultivated separately, had resistant cells. From these resistant cultures he isolated a filterable agent which induced resistance to RSV in sensitive cultures. This agent, named Rous Interfering Factor (RIF) had particles the same physical size as RSV, was neutralized by serum prepared against RSV, and its action in tissue culture could be mimicked by four different strains of tumour-producing VL virus. These facts strongly indicate that RIF might in fact be the virus of VL. Virologists can now use the extent of inhibition of RSV by RIF as a measure of the amount of RIF present in the culture. It is envisaged that this interference method of the detection of RIF may also form a tool to investigate the cause of some other mammalian tumours of unknown, and presumably viral, origin.

BOOKS

Theory and statistics in psychology

by Sir CYRIL BURT

EXPERIMENTS IN PERSONALITY. Edited by H. J. Eysenck. Vol. I: Psychogenetics and Psychopharmacology. Vol. II: Psychodynamics and Psychodiagnostics. (Routledge & Kegan Paul, 262 pp., 334 pp., 40s. per vol.)

"MODERN PSYCHIATRY", we have been told, "consists of a hotch-potch of speculative theories—nineteenth century materialism jostling with twentieth century Pawlow and Freud—and no reliable research techniques for deciding the issues between them." It has been Professor Eysenck's aim to wipe out this reproach. The means he proposes are, first, the application of objective tests for mental symptoms and other psychological characteristics; and, secondly, the use of rigorous statistical procedures for analysing the data thus obtained. The two volumes which he has now edited form an interim report on the results so far achieved by himself and his collaborators at the Institute of Psychiatry.

The series opens with a contribution from Dr. P. L. Broadhurst on the basic problems of mental genetics. "Without an understanding of heredity", he argues, "clinical psychology is bereft of knowledge of about half the influence at work." For obvious reasons experiments on breeding have to be undertaken, not with human beings, but with humbler animals such as mice, rats and dogs. Dr. Broadhurst begins with an illuminating survey of the researches carried out in this field from the days of Galton onwards, and then describes experiments of his own on the inheritance of certain measurable types of behaviour in six strains of rats. The methods which he has adopted mark a great improvement on those employed by earlier investigators; and, unlike the majority of his predecessors, he lays chief emphasis, not on the more familiar unifactorial types of transmission associated with Mendel's name, but on the effects of multifactorial inheritance, which, as recent studies have shown, serves so admirably to elucidate the wide individual differences in innate ability found among human beings.

The remainder of the first volume is concerned with the light thrown on variations in personality by testing the

effects of drugs. In common with other psychologists, Professor Eysenck holds that one of the most distinctive characteristics of each individual, whether normal or neurotic, is the degree to which he inclines towards extraverted or an introverted type of behaviour. These contrasted tendencies, so he believes, depend on the varying balance maintained within the brain between excitation on the one hand and inhibition on the other. Stimulants, such as strychnine or benzedrine, operate either by increasing cortical excitation or by decreasing inhibition or both. They will therefore, so it is somewhat paradoxically contended, have the effect of temporarily enhancing introverted characteristics—shyness, irritability, obsessiveness, and the like. Depressants, such as chloral or the barbiturates will, according to the same reasoning, tend to enhance the opposite or extraverted characteristics.

The experiments reported here merely represent the first attempts at checking some of these hypothetical expectations. They are concerned principally with the effects of two depressant drugs—meprobamate (commonly classified as a tranquillizer) and doriden (classified as a hypnotic). The tasks prescribed included tests of discrimination, learning, vigilance, quickness of reaction and variations in skin resistance to electrical currents (a phenomenon generally regarded as an index of emotional disturbance). So far as these preliminary studies take us, it appears that on the whole the results are in keeping with the general theory they were intended to test. The volume ends with an instructive paper by Professor and Mrs. Eysenck outlining a new and promising statistical technique for securing a more scientific classification of drugs according to their psychological effects.

Much of the second volume is occupied with various theoretical investigations of the "excitation-inhibition balance" in normal and abnormal individuals. But from the practical standpoint perhaps the most important contribution is the study of disturbances in logical thinking manifested by psychotic patients. Various hypotheses have been put forward to explain the inner

mental life of schizophrenics. The earliest account supposed that they suffer from a deep-seated mental dissociation issuing in what is popularly called "split mind". Several later writers have held that their basic disability is a pathological slowness of thought; others that they tend to overgeneralize and are thus prone to erratic delusions, and others again that they fail to generalize, and are therefore unable to think rationally. Professor Payne and Dr. Hewlett have endeavoured to decide the issues thus raised by applying formal tests. The main outcome of their work is to show that the diagnosis of schizophrenia includes a very mixed assortment of patients belonging to widely different subgroups, some displaying one type of symptom, others very often the opposite.

Up to now, as the authors themselves are the first to admit, the positive results of all these inquiries are somewhat meagre. The chief interest of their work springs, not from the conclusions reached, but from the new procedures they have employed. The critic may perhaps wonder whether, in their enthusiasm for experimental tests and statistical analysis, they have not been tempted to neglect what, in dealing with disease, still remains the richest source of information—the direct observation by trained clinicians. But that, after all, is an omission which future researches may readily repair.

The new look in organic chemistry

AN INTRODUCTION TO ELECTRONIC THEORY OF ORGANIC COMPOUNDS. By H. L. Heys. (Harrap, 236 pp., 16s.)

THE last twenty-five years have seen an enormous extension in our knowledge of the reactions of organic compounds and, in particular, of the actual mechanisms by which these reactions take place. This has largely come about from the application of electronic theories to organic chemistry and has resulted not only in a systematization of the vast mass of disparate information already

BOOKS *continued*

available, but has also made it possible to forecast the conditions necessary for the successful carrying out of a number of new and useful reactions. The advantage of the new approach is that, far from requiring a chemist to know more, it enables him to make much better use of what he does know.

This new look in organic chemistry has gradually become embodied in the larger text-books and monographs and is now slowly filtering down to the more elementary stages of chemical education. The present book is intended as a treatment suitable for the scholarship boy in the sixth form and for those beginning their professional career at university or technical college. The first half deals with valency theory and the factors influencing the reactivity of organic compounds, and the second half with substitution, addition and elimination reactions involving both ionic and free radical mechanisms. It is in this distribution that the reviewer believes the book fails. It is important at this level that the student should be afforded an early opportunity of seeing how the new ideas work out in practice, in interpreting the course of reactions and in forecasting the effects that changes in conditions might be expected to have on them. Here he has to wait too long, and too little space is then left for the effective demonstration of the generalizations that are the life blood of the new approach. This is a brave try at a difficult job, but the more elementary student still awaits his interpreter.

PETER SYKES.

Bacterial polysaccharides

POLYSACCHARIDES OF MICRO-ORGANISMS. By M. Stacey and S. A. Barker. (Clarendon Press: Oxford University Press, 228 pp., 30s.)

THE importance of bacterial polysaccharides, not only to the carbohydrate chemist, but also in immunological studies, biology and medicine, makes this book a valuable source of information in many fields of scientific investigation. It is the first text-book devoted entirely to polysaccharides of micro-organisms, and the first collection of the widely scattered chemical knowledge of these macro-molecules.

The introductory five chapters are written for the non-specialist, and in the first of these carbohydrate nomenclature, the formulae of the simple sugars and the way in which they are linked together in the macro-molecules of the polysaccharides are clearly illustrated. The second chapter describes not only the wide diversity of monosaccharides

found in the polysaccharides, but also the rare sugars incorporated in the antibiotics elaborated by micro-organisms, the authors being of the opinion that these sugars will, in the future, be found in polysaccharides. This chapter concludes with a short description of the recognized pathways in the biosynthesis of monosaccharides.

The next two chapters are full of interest, and describe respectively the main functions of bacterial polysaccharides and the techniques involved in the isolation of homogeneous polymers. In fewer than thirty pages in Chapter V the authors describe the current methods in use for the determination of the constitution and structure of polysaccharides. Although clearly and concisely written, this chapter would have been still more valuable to the reader if greater space had been allocated to it, since the field is now too wide for so short a treatment.

The remaining seven chapters which constitute the greater part of the book

authoritatively summarize the constitution and structure, in so far as they have been established, of the polysaccharides synthesized by rickettsiae, Gram-negative and Gram-positive bacteria, higher bacteria (such as *Mycobacteria*, *Actinomyces* and *Leptospira*), moulds, yeasts and yeast-like fungi and protozoa. These chapters contain a great deal of information, and the numerous tables provide invaluable data on the polysaccharides of *Chromobacterium*, *Escherichia coli*, *Aerobacter*, *Salmonella*, *Shigella*, *Pneumococcus*, *Leuconostoc* and *Bacillus* spp.

A salient feature of the book is the extensive bibliography at the end of each chapter. Although nothing after 1957 is included, a brief account of more recent work is given in an appendix with relevant references. The book is clearly printed, easy to read, illustrated with excellent formulae and is a worthwhile purchase for anyone interested in micro-organisms.

ELIZABETH PERCIVAL.

Birds of the West Indies

BIRDS OF THE WEST INDIES. By James Bond. (Collins, 256 pp., 35s.)

THE West Indian avifauna is rather poor in species compared with that of other tropical areas of equal extent, but for that reason it is not unmanageable. The visiting ornithologist can quite easily see a great many of the most interesting forms: as Dr. Bond points out, there are not many species that cannot be seen from the roadsides. Most of the species are of Northern or Central American origin, but isolation has been long enough to have produced several endemic genera and two endemic families.

Dr. Bond's new book is one of the growing number of well illustrated regional handbooks of bird identification. It succeeds the same author's two earlier books on the birds of the West Indies (1936 and 1947), and as well as incorporating later knowledge it gains much by the addition of eight excellent colour plates by Don Eckelberry depicting 80 species. A further 186 species are competently illustrated in line drawings by Earl Poole. Thus well over half of the 429 described species are portrayed, and most of those that are not are either very similar to an illustrated species or are migrants from the north and hence covered by the standard North American bird guides.

The systematic section takes up the greater part of the book. For each species there are sections under the

headings "local names", "description", "voice", "habitat", "nidification" and "range". There is also a brief but informative introduction to each family. Finally there is a list of vagrants. The information is brief, but adequate for its purpose and authoritative.

The primary purpose of the book is identification, and this purpose is very well served. One would perhaps have welcomed a short introductory chapter devoted to a discussion of the origin of the West Indian avifauna, migration in and through the West Indies, breeding seasons and other biological aspects. The statement in the preface that "there is no well-marked breeding season for many of the commoner West Indian birds, such as hummingbirds, bananaquits and grassquits" makes one want to know more, since the area dealt with, lying between the latitudes 12° and 26° N., is by no means equatorial and definite breeding seasons would be expected. A chapter on such topics would enhance the book's value even for the casual birdwatcher.

In his preface the author stresses the need for bird protection in the West Indies. The land areas are mostly small, several species have been exterminated in historic times and others are threatened today. It is to be hoped that his book will increase local interest in West Indian birds and lead to a climate of opinion in which effective measures can be taken for their conservation.

D. W. SNOW.

LETTERS

UNESCO takes to the seas

Sir,—I read with interest your report in the issue of 15 December concerning the setting up of an International Oceanographic Commission. I fear, however, that the financial estimate of \$60 million to undertake a complete survey of the world's oceans, is a considerable under-estimation.

The employment of 15 ships working full time for 20 years is envisaged in order to fulfil this herculean operation. Itemizing the running costs of such ships would be a lengthy business; it is reasonable to suppose, however, that they would be substantial vessels, built to withstand long sea voyages, and equipped with the latest oceanographical instruments. To man each one a crew of at least sixty would be required. The wages for these small numbers alone over the period envisaged would amount to nearly \$40 million!

It is not unreasonable to estimate \$1,000 a day per ship for the total expenditure on such vessels. If one is to include major repairs and overhauls necessitated by long periods at sea, and ship depreciation (a major consideration over 20 years), a figure of \$2,000 a day might well be more realistic.

Oceanography does not end with the ships, obviously. The analysis and evaluation of all work undertaken at sea remains to be carried out ashore.

I would suggest a revised figure of between \$150 million and \$200 million to be nearer the mark. Perhaps one can derive solace from this much-inflated figure; with 80 per cent of the Earth's surface still virtually unknown, the value of such an enormous project cannot be assessed in normal terms.

C. J. C. WYNNE-EDWARDS,
Lieutenant-Commander, R.N.
H.M. Surveying Ship *Scott*,
c/o GPO, London.

Roman nails

Sir,—I was very interested to read in *Notes and Comments* (8 December) of the discovery of the "mint" condition of the quantity of Roman nails abandoned by Agricola's Legion at Inchtuthill. I have a ship's chain of reputedly Roman origin—although Caesar mentions that only the Veneti used mooring chains on their galleys—which was dredged from the Thames and none the worse for its long immersion; although one end of the chain is worn to half the thickness of the other, the smith's hammer marks are still pronounced. I have also marvelled at the incorruptibility of this metal, but being not mechanically minded was astonished to read that there was some secret in its production.

I thought that all these problems were solved long ago when it was first learned that the early metal workers did not allow the metals to become cast but beat them out of the hot ore with mighty hammer strokes!

I re-examined some pieces of slag—some of it metalliferous—and discovered other factors which may account for the barrier against erosion. The slag was collected from an early metal-working site which produced, also, a quartzite hammer stone. The geology of the district is chalk with flints. The ores and precious metals must have been brought from elsewhere as the charcoal for the furnaces has been burnt there into comparatively recent times. The appearance of some of this slag has puzzled a professional archaeologist as it is mixed with pieces of tough shell—possibly giant *Inoceramus*—and patches of black vitreous material which may be calcined silicon mixed with charcoal under heat and pressure, being mindful of the high oxygen content of silicon! Beaten into the hot metal this should prove an adequate barrier against moisture homogeneous to it. We know the effect of bone ash on china clay, so that it is possible that these ancient metal workers stumbled on the primitive method of hardening metal. A tiny "tear" of precious metal caught between a piece of shell and slag defies all simple methods of extraction from its hard matrix.

The Dhar column mentioned by Sir Alexander Fleck which has remained inviolate by rust for sixteen hundred years may have been smelted by this method, and the theory of being coated with a fine layer of the adherent slag is apparently correct. Iron metallurgy must have been closely linked with that of the precious metals in this country and disappeared with the Celts into the Dark Ages and the volcanic regions of North Wales, Ireland and Scotland. I have taken out partially rusted nails from the Mendip region where the dolomitic limestone splits rather than fuses. This is a problem for folk more highly qualified myself, and it would be intriguing to establish whether silicon as a barrier was lost to be only recently rediscovered as a servant of industry.

DOROTHY E. WARREN.

30 Oakley Street,
Chelsea, S.W.3.

Sir,—It would seem inconceivable at first thought that there is any connection between the Roman nails found in good condition at Inchtuthill and the iron column at Delhi, but on second thoughts the material for the manufacture of both could just possibly have come from the same place and ore. If

the analysis of both were proved to be identical, then we might start on a fascinating search for the mine.

A. H. ANDREWS, Principal,
Poole College for Further Education,
Parkstone, Poole, Dorset.

Hydrofoil boats

Sir,—Concerning your note on hydrofoil boats (24 November), the system employed by the PC-H is not basically novel, but is directly devised from incidence control, which I pioneered and which was first reported on by the RAE technical report in 1947.

I could have easily covered other means of sensing the surface if I had found a little support in Britain.

CHRISTOPHER HOOK.
c/o Huso Verft,
PO Box 68,
Tonsberg, Norway.

Photons as eels?

Sir,—Thank you for the delightful account of Professor Jánosy's experiments involving single photons (8 December). But the results of "Experiment 3" would also be explained if each photon either were, or left a wake, like an undulating eel of many metres long. The head end of one eel would interfere, by phase difference, with the tail end of the one in front. Thus one would like to see Experiment 3 repeated, with photons being fed into the system less and less often, until a condition might be reached when no interference occurred at all. That, if it happened, would give the length of the eel.

MAX PETTERSSON.
9 Mellows Road,
Ilford.

The machine tools controversy

Sir,—In his critical survey of the Government advisory committee reaction to the Melman Report on mass producing machine tools, Professor Tobias (*The machine tools controversy*, 1 December) made a comment which merits further discussion in terms of its logic. He asserted "that the [British] sub-committee was completely wrong in one case" and followed this up by arguing that "suspicion grows that perhaps some of the other specific recommendations of the Melman Report [which had been rejected] should also merit further consideration". I suggest that this line of thought is not valid. Accuracy in humans or machines is surely a probability phenomenon. This is the implication of all school and

LETTERS *continued*

university marking systems, which must include that at Birmingham, and it is explicitly the basis of statistical industrial quality control. When the first error or false conclusion is found in a candidate's answer paper it is not taken as indicating that the rest of the paper is at fault. It is the proportion of error that is used as a probability rating for the candidate.

In practice, it seems to me, we tend to use this approach in assessing situations where we have no strong emotional tie. But where an advocate is arguing a

case, he often uses a flaw in his opponent's reasoning in the same way as Professor Tobias has done. When the reasoning is wholly *in series*—one conclusion forming a premise for further reasoning leading to a further conclusion, and so on—there is some justification for this.

But most cases involve a number of parallel strands of argument which are then woven — possibly with other multiple strands of argument—into a fabric of main conclusions. For such cases a weakness in one line of argu-

ment, in the same idiom, may make an ugly mark and a weakness in the cloth but does not necessarily cause it to fall apart.

On the other hand if one finds a number of false premises, fallacies presented as facts, or illogical conclusions then this truly makes the fabric rotten, damning the argument as it does a candidate.

I. BERKOVITCH.

10 Seymour House,
Albion Avenue,
London, SW8.

COMPANY MEETING

Arthur Guinness Son & Company Limited

THE EARL OF IVEAGH ON A RECORD TRADING ACHIEVEMENT

The Annual General Meeting of Arthur Guinness Son & Company Limited will be held on 12th January 1961 at Park Royal Brewery, London, N.W.10, and immediately following that Meeting an Extraordinary General Meeting will be held to approve a Capitalisation Issue of 2 new Ordinary shares of 10/- for every 5 Ordinary stock units of 10/- each registered on 12th December 1960.

It is proposed to recommend payment of Final Dividends on 13th January 1961 of 3% on the Preference Stock and 20% on the Ordinary Stock, all less Income Tax.

The following is an extract from the statement by the Chairman, The Earl of Iveagh, K.G., C.B., C.M.G., circulated with the Report and Accounts for the year ended September 30, 1960:

The Accounts show that the gross and net profits are both our highest yet achieved. This is due in part to the satisfactory and expected recovery from the temporary effect of the special conditions of 1959 to which I drew attention last year. The improvement in our sales in the latter months of that year which I then indicated has continued. Since our primary and main purpose is to sell those Five Million Glasses a day to which attention has been so dramatically drawn on the hoardings during the summer, I am glad to say that it is to sales of Guinness that the improvement in this year's accounts is due—both in Great Britain and in Ireland and overseas. Although as I said a year ago the wonderful summer of 1959 did not assist us as it did other brewers, yet fortunately we do not depend for our success and progress on the sort of summer and autumn which we have just endured. This year's trading has in fact once again fallen into line with the pattern which we had been successfully following through most of the 50's.

PROPOSED CAPITALISATION

Commenting on an eight year survey of results contained in the Report, the Chairman said: In this period over £17 millions have been retained in the business, partly in the form of depreciation but mainly undistributed profits. A large amount has necessarily been used in keeping our whole plant modernised in every way, including the almost complete change-over in this country, and the large scale turnover in

Ireland, from timber in every form and use to metal. Other amounts have been committed to new activities or for the extension of our present activities such as our ale market in Ireland, and to finance our move during last summer into the lager market. This deploying of a large part of our retained profits into fixed assets means that once again we find that your Company's investment in assets that are permanently engaged in manufacture and trade is getting out of balance with the amount of the issued capital; and we propose to bring that capital more into line with the true position by capitalising some part of those undistributed profits of past years, which are now locked up in productive plant to the ultimate benefit of the Company and its shareholders and everyone connected with it.

It is proposed to capitalise £5,000,000 by issuing two new 10s. Ordinary shares for every five 10s. Ordinary shares held and so bring the issued Ordinary capital of the Company up to £17,500,000. This does not in itself affect in any degree the value of an Ordinary shareholder's interest in the equity; but we would not have proposed the operation if we had not been convinced that this properly represents the increased strength of the Company which in good time we are confident will be reflected in further progress and profits. Meanwhile the proposed increased dividend for the year under review emphasises the continuation of the steady rise that has been taking place in the post-war years.

NEW PRODUCTS AND DEVELOPMENTS

I have referred to our ale brewing in Ireland. There we have entered into discussions with Messrs. Ind Coope to join forces in regard to the production of ales for the Irish market; this should be a happy combination and one we believe of importance to Irish ale brewing. This new arrangement should be in force early in 1961.

Meanwhile as I hope all our shareholders know we have successfully launched on the Irish market our new lager, called Harp. This is brewed at Dundalk and was necessarily on a small scale initially; but we are now very considerably extending the brewery. We have always made it clear that we should be

bringing Harp Lager over from Ireland to Great Britain; and we propose to start this trade in 1961 with further expansion in 1962. Recently we have agreed in principle with Messrs. Courage Barclay & Simonds to the joint brewing and distribution of lager in England. We have taken this step because it is obvious that there is and will be, as we believe, increasingly a demand for drinks of the lager type.

EXPORT EXPANSION

Our Exports have continued to rise. Spread as we are over virtually the whole world, it is inevitable that there must always be spots where conditions are for the time being adverse; this year for instance we have been completely shut out of Cuba and Venezuela. Our still growing and marked success in some directions bring, as I mentioned last year, their own problems; and we have been closely considering how best to consolidate and extend our position in Nigeria. It is our present view that we should establish a full brewery there in the near future. We have already established local marketing companies in Nigeria, as well as in Ghana, and the Caribbean; and a marketing company in Sierra Leone will follow shortly.

TRIBUTES

Referring to the retirement at the end of the year of Sir Hugh Beaver, the Managing Director of the Company, the Chairman recalled the momentous decision in 1932 to build a Brewery in London, the work being undertaken by Sir Alexander Gibb & Partners and Sir Hugh Beaver placed in charge. Sir Hugh joined the Board on 1st December 1945 and became Managing Director on 8th November 1946. The Chairman added: "All his colleagues, and myself in particular, consider this as one of the many pieces of good fortune with which the firm has been blessed for two hundred years. The Brewing industry as a whole has also greatly benefited by Sir Hugh's services, and the peoples of Great Britain and Ireland owe much to his manifold activities in the fields of industry."

After reviewing the Company's other activities the statement concluded with a tribute to all the Company's staff and employees for their work during the year.

CONTRIBUTORS

1960 Science Survey

HAROLD EVERARD MONTEAGLE BARLOW is Pender Professor of Electrical Engineering at University College, London.
(page 1685)

MICHAEL JAMES LIGHTHILL is Director of the Royal Aircraft Establishment, Farnborough.
(page 1686)

SIR JOHN DOUGLAS COCKCROFT is Master Designate of Churchill College, Cambridge, and lately Director of the Atomic Energy Research Establishment, Harwell.
(page 1686)

SIR HARRIE STEWART WILSON MASSEY is Quain Professor of Physics at University College, London, and Chairman of the British National Committee on Space Research.
(page 1687)

SIR HENRY HALLETT DALE was Director of the National Institute for Medical Research, Hampstead, from 1928 to 1942, and during the succeeding four years was Director of the Laboratories of the Royal Institution and Fullerian Professor of Chemistry.
(page 1687)

MAURICE HUGH FREDERICK WILKINS has been Deputy Director of the Biophysics Research Unit of the Medical Research Council since 1955.
(page 1688)

STANLEY KEITH RUNCORN is Professor of Physics and Director of the Department of Physics at King's College, Newcastle upon Tyne.
(page 1689)

NIGEL CALDER (*Jules Verne's Lunik*) is Science Editor of *The New Scientist*.
(pages 1690, 1691)

ALFRED EMIL ANTHONY WERNER (*How modern chemistry conserves antiquities*) was educated at St. Gerard's School, Bray, Co. Wicklow, Trinity College, Dublin, and the University of Freiburg im Breisgau. He returned to Trinity College in 1937 as a lecturer in chemistry and then as Reader in Organic Chemistry, and in 1948 he became a research chemist at the National Gallery, London. He joined the British Museum as a Principal Scientific Officer in 1954, and four years later was appointed Keeper of the Research Laboratory at the Museum, the post he holds at present. He is author of *The Scientific Examination of Paintings*. He is married, with two daughters, and he likes chess and travelling.
(pages 1693-1696)

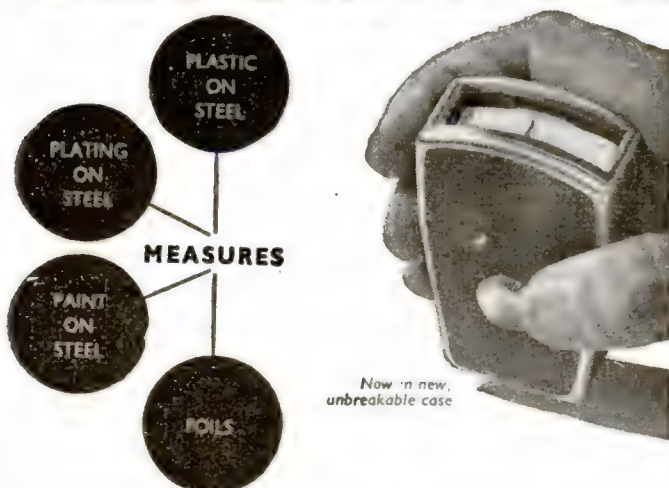
GORDON THOMAS WRIGHT (*When insulators conduct*) was educated at the George Dixon Grammar School, Birmingham, and at the University of Birmingham. He spent three years in South Africa as a lecturer in physics at Rhodes University, and then became Senior Physicist at the Mullard Research Laboratories. He returned to Birmingham University as Lecturer in Electrical Engineering in 1956, where he has worked on solid-state electronics and the physics of semi-conductors and dielectrics. He is married and has three children.
(pages 1704-1707)

CHARLES HERBERT GREENE (*Pyroceram*) was educated at Haverford College and Harvard University, where he obtained his PhD in chemistry. After working as a chemistry instructor at Harvard and as a research chemist at the Corning Glass Works, he became Professor of Glass Technology at the New York State College of Ceramics in 1953.
(pages 1708-1710)

SIR CYRIL LODOWIC BURT (*Theory and statistics in psychology*) was educated at Christ's Hospital, Jesus College, Oxford, and Würzburg University. For nineteen years he was Psychologist to the Education Department of the London County Council. He is editor of the *British Journal of Statistical Psychology*. He was knighted in 1946. Among his many books are *The Distribution of Educational Abilities*, *The Young Delinquent*, *The Measurement of Mental Capacities* and *How the Mind Works*.
(page 1714)

THE

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Opportunities for science and mathematics graduates to teach in secondary schools.

The London County Council will be pleased to consider applications for salaried appointments in its teaching service, both full-time and part-time, from science or mathematics graduates, who are prepared to take a full-time six weeks' (non-residential) refresher course, which will include a period of two weeks' observation in schools, to prepare them for science or mathematics teaching. No fees are payable for the course, which will be held at the Westminster annexe of Avery Hill Training College at Horseferry Road, S.W.1. This offer should appeal particularly to married women and other science or mathematics graduates who either have had no teaching experience or have been out of teaching for some time. It is not intended for men and women who have just graduated. In considering science graduates preference will be given to those qualified to teach physics and/or chemistry. Applicants will be interviewed towards the end of January 1961 and those accepted will be appointed to the Council's service and paid salary continuously from 17th April, 1961, including the period of the course. Salary (Burnham Scale) will depend on qualifications and experience. For further particulars and application form send a stamped addressed foolscap envelope to the Education Officer, (TS.1/NS/3010/12), County Hall, Westminster Bridge, S.E.1. immediately.

UNIVERSITY OF ALBERTA, EDMONTON AND CALGARY, CANADA

Applications are invited for ASSISTANT PROFESSORSHIPS in PHYSICS at both divisions of the University of Alberta, salary \$7,000 up, according to experience. Excellent facilities for research are available, in new buildings. Specialties are Theoretical Physics, Nuclear Physics, Low Temperature, Geophysics, at Edmonton; Cosmic Radiation, Biophysics, at Calgary.

For further information write:

Professor H. Grayson-Smith
Head
Department of Physics
University of Alberta
Edmonton, Canada.

UNIVERSITY OF WESTERN AUSTRALIA

LECTURESHIP IN GEOGRAPHY

Applications are invited for appointment to the above-named position in the Faculty of Economics. Preference will be given to candidates with training and/or publications in the field of human and economic geography. The salary range for the position is £A1,750/75/2,350 per annum with superannuation similar to F.S.S.U. Candidates are requested to state whether they have specialised in any regional field and, if so, to specify the area. The appointee will be expected to take up duty as early as possible in 1961.

It is important that intending applicants obtain details of the procedure to be followed in applying for the post and a copy of the Conditions of Appointment, before submitting their applications. This information is available from the Secretary, ASSOCIATION OF UNIVERSITIES OF THE BRITISH COMMONWEALTH, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on 25th FEBRUARY, 1961.

UNIVERSITY OF SOUTHAMPTON

Department of Aeronautics and Astronautics. Applications are invited for the post of LECTURER or ASSISTANT LECTURER in either hypersonics or noise and vibration theory. Candidates should have a good Honours degree in Engineering, Mathematics or Physics together with suitable experience in hypersonics or noise and vibration theory. Salary Scales: Lecturer £1,050 x £50-£1,400 x £75-£1,850 with an efficiency bar at £1,475. Assistant Lecturer £800 x £50-£950. The initial salary will depend on qualifications and experience. Further particulars should be obtained from the Secretary and Registrar, The University, Southampton, to whom applications (7 copies from United Kingdom applicants) should be sent not later than 13 February, 1961.

UNIVERSITY OF WALES

UNIVERSITY COLLEGE OF SWANSEA

DEPARTMENT OF ENGINEERING

Owing to the large expansion of the Departmental facilities for both teaching and research, a number of appointments will be made to the Staff both immediately and from October 1st, 1961. Applications are invited from graduates in Engineering, Physics, Metallurgy or Applied Mathematics for the following posts:

CIVIL ENGINEERING

Professor B. G. Neal

LECTURER or Assistant Lecturer with interests in any branch of Civil Engineering.

CIVIL OR MECHANICAL ENGINEERING

LECTURER or Assistant Lecturer with special interests in Strength of Materials and related fields.

MECHANICAL ENGINEERING

Professor R. H. Macmillan

TWO LECTURERS or Assistant Lecturers, one with particular interests in the fields of Heat Transfer and Thermodynamics, the other preferably having experience in the Design of Machines, but applicants with other interests will be considered.

RESEARCH DEMONSTRATOR to undertake a limited amount of teaching and pursue supervised research preferably in Heat Transfer, Hydrodynamic power transmission, Fatigue or creep.

ELECTRICAL ENGINEERING

Professor W. Fishwick

LECTURER or Assistant Lecturer with special interests in Control Engineering, Electrical Apparatus or related fields.

LECTURER or Assistant Lecturer with interests in any branch of Electrical Engineering, including Theoretical Electro-technics.

Qualifications for, and further details of, these posts are as follows:

LECTURER. Applicants should hold a good Honours degree and have not less than three years' post-graduate experience in research or industrial design. Excellent facilities exist for research.

ASSISTANT LECTURER. Applicants should hold a good Honours degree and have at least one year's industrial or post-graduate experience. Research is strongly encouraged and the assistant may register for a Ph.D. degree.

RESEARCH DEMONSTRATOR. Applicants should have obtained a good Honours degree and have had at least one year's industrial or post-graduate experience. The appointment will be tenable for three years, during which time the holder will be expected to work for the Ph.D. degree, submitting a thesis at the end of the period.

Salaries are on the following scales, to which are added F.S.S.U. benefits and family allowances.

LECTURER: £1,050 x £50 to £1,400 x £75 to £1,850 per annum.

ASSISTANT LECTURER: £800 x £50 to £950 per annum.

RESEARCH DEMONSTRATOR: £700 per annum.

Further particulars can be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications (two copies) must be received not later than SATURDAY, JANUARY 21, 1961.

UNIVERSITY COLLEGE OF RHODESIA AND NYASALAND

Applications are invited for Lectureships or Assistant Lectureships in:

GEOLOGY MATHEMATICS PHYSICS

Salary Scales: Assistant Lecturer £1,200 x 50-£1,350 p.a., Lecturer Grade II £1,350 x 50-£1,600 p.a., Grade I £1,600 x 50-£1,900 p.a. Passages to Salisbury for appointee, wife and dependent children on appointment, with allowance for transport of effects. Superannuation and Medical Aid Schemes. Unfurnished accommodation at rent of 15% of salary. Assistance given for triennial visits overseas. Detailed applications (6 copies) naming 3 referees by 30 January 1961 to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF ABERDEEN

and

ROBERT GORDON'S COLLEGES

Applications are invited for the post of UNIVERSITY LECTURER in MECHANICAL ENGINEERING. Candidates should have special qualifications in applied thermodynamics. An interest in Heat Transfer apparatus and some industrial or research experience would be an advantage. Excellent facilities for research or advanced studies. University regulations permit members of teaching staff to read for degree of Ph.D. by research. Salary on scale £1050-£1850 with placing according to qualifications and experience. University houses available from time to time. Appointment to date from as early as possible in 1961. Further information may be obtained from the Secretary, The University, Aberdeen, with whom applications (20 copies), giving the names of three referees, should be lodged not later than 31 January, 1961. Applicants outside the British Isles may submit one copy of application.

WELSH COLLEGE OF ADVANCED TECHNOLOGY Cathays Park, Cardiff.

DEPARTMENT OF APPLIED PHYSICS

Applications are invited for the posts of

- LECTURER or ASSISTANT LECTURER (Grade B) in Electronics.
- ASSISTANT LECTURER (Grade B) in Physics.

Applicants should have a good honours degree in Physics or Electrical Engineering, and be able to teach (a) Electronics and/or Telecommunications, (b) Physics and/or Applied Physics, to students taking Dip. Tech. Courses, and have had industrial and/or research experience. Teaching experience at University or Technical College level would be an advantage. Successful candidates would be expected to pursue some research and every assistance and encouragement will be given to this end. The Department's research activities are largely confined to Solid State Physics and application from those particularly interested in some aspect of Solid State Physics or Applied Physics would be particularly welcome.

SALARY

- Lecturer £1,370 x 35-£1,550 p.a.
- Assistant Lecturer (Grade B) with good honours degree £865 x £27.10.0 to £1,315 p.a. Starting salary according to qualifications.

Further particulars and application forms can be obtained from the Registrar at the College, to whom they should be returned by 14th January, 1961.

ROBERT E. PRESSWOOD
Clerk to the Governing Body.

THE UNIVERSITY of MANCHESTER

Applications are invited for the following posts in the Department of Physics of the Faculty of Science.

LECTURER IN PHYSICS (Experimental) LECTURER IN THEORETICAL PHYSICS ASSISTANT LECTURERS IN PHYSICS

The research interests of the Department include Nuclear and High-Energy Physics, Optics, Low Temperature and Molecular Physics. Duties to commence as soon as possible. Salary scales: Lecturer, £1,050 to £1,850 per annum, initial salary according to qualifications and experience; Assistant Lecturer £800 to £950 per annum. Membership of F.S.S.U. and Children's Allowance Scheme. Applications must be sent not later than January 14th 1961 to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained. Applications by airmail letter in the first instance will be received from overseas candidates, who should state the names and addresses of at least three persons to whom reference can be made.

SENIOR BOTANIST WEST AFRICAN COCOA RESEARCH INSTITUTE, GHANA

To take charge of the Botany Division comprising plant breeding and plant physiology sections.

Candidates must have a first or second class honours degree in Botany or equivalent qualification, with at least 15 years' research experience and a good record of published work. Proven ability to plan and supervise research programmes and experience with tree crops, preferably in the tropics, is also desirable.

Appointment on contract/gratuity terms for two years each of 15-18 months in the first instance. Salary in scale £2460-£2940. Gratuity £12 10s. for each month of satisfactory service. Quarters with heavy furniture provided at moderate rental. Free return passages once in each year for officer, wife and up to three children under 18 years of age. Generous leave. Educational allowances.

Apply stating name in full and giving brief particulars of qualifications and experience, to Director of Recruitment, COLONIAL OFFICE, S.W.1, quoting BCD 197/200/028/D45.

UNIVERSITY OF QUEENSLAND SENIOR LECTURER IN GEOLOGY (GEOCHEMIST)

Applications are invited for the above-mentioned post, which is a responsible teaching position with excellent opportunity for geochemical and petrological research in a large University. Applicants should have a Science degree and research experience to Ph.D. or comparable level; present dominant interest should be in Geochemistry (theoretical and economic). Some experience in rock and mineral analysis and ability to do fundamental research is expected. An interest in isotope Geology and at least some experience in mass spectrometry is desirable. Some interest in X-ray spectroscopy or other special techniques could be an advantage.

Salary £A2520-£A70-£A2870 per annum. The successful applicant will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.

Further particulars may be obtained from the Secretary, ASSOCIATION OF UNIVERSITIES OF THE BRITISH COMMONWEALTH, 36 Gordon Square, London, W.C.1.

Applications close, in Australia and London, on 31st MARCH, 1961.

UNIVERSITY OF QUEENSLAND LECTURER IN PROTOZOLOGY

Applications are invited for the above-mentioned post within the Department of Parasitology. Applicants should have a Ph.D. or a Degree in Veterinary Science with post-graduate experience in Protozoology. Duties will be primarily teaching and research on the parasitic protozoa within the Faculties of Science and Veterinary Science, but it is desirable that applicants should also have knowledge and experience of parasitic arthropods particularly those of Veterinary importance. Salary range £A1830-£A70-£A2330.

The successful applicant will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.

Further particulars may be obtained from the Secretary, ASSOCIATION OF UNIVERSITIES OF THE BRITISH COMMONWEALTH, 36 Gordon Square, London, W.C.1.

Applications close, in Australia and London, on 28th FEBRUARY, 1961.

D.S.I.R. Road Research Laboratory, Harmondsworth, Middlesex, requires Scientific Officers or Senior S.O.'s for research: (1) **PHYSICISTS** on rheology of solid-liquid systems and of viscous and visco-elastic fluids to provide basic information for design of bituminous and concrete road mixtures. (Ref. A.521/OA); (2) **CHEMISTS** on problems of surface chemistry and other physico-chemical aspects of behaviour of bituminous road materials; also on problems arising from presence of organic matter in soils. (Ref. F.857/OA); (3) **CIVIL and MECHANICAL ENGINEERS** on (a) mechanical mixing and laying of bituminous road surfacing materials, (b) problems of design and construction of earthworks for roads (practical experience of site work an advantage), (c) stabilised soil and cement-bound base materials. (Ref. E.473/OA). Varied and interesting work both in laboratory and field, providing contacts with other scientists and engineers in U.K. and abroad. Facilities for qualifying for A.M.I.C.E. for posts (3) above. Quails, 1st or 2nd class Hons. degree or equiv. for S.S.O. at least three years' post-graduate experience. Salary (men) S.O. £730-£1,205. S.S.O. £1,330-£1,640. Prospects of promotion in mid-thirties to P.S.O. £1,700-£2,375. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote appropriate reference). Closing date 31 January 1961.

MINISTRY OF AVIATION require **ELECTRICAL ENGINEERS** as assistant signals officers. Posts mainly in London but some in provinces.

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SALARY SCALE £690 (at age 23) to £1,300. Slightly lower for women and for posts outside London. Promotion prospects. Further details and forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.161/OA.

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Location of post is in the British Iron and Steel Research Association's laboratories at Sheffield, with visits to research establishments here and abroad, as required. Starting salary depending on qualifications and experience, but not less than £1,350. The post is superannuated under the F.S.S.U.

Written applications only quoting "M.W.21" to the Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1

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IRON AND STEEL

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Written applications only quoting M.W.20 to the Personnel Officer, The British Iron and Steel Research Association, 11 Park Lane, London, W.1.

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Graduate, preferably with several years' experience, required for research project on the beneficiation of iron ores and other minerals used by the iron and steel industry. Research includes both fundamental and process studies on the sintering of iron ores. Applicants should have qualified in mineral dressing, physical chemistry or chemical engineering. The salary offered will be in the range £1,100-£1,600 p.a. depending on experience. The post is a long term one and carries superannuation. The Company is prepared to assist with housing.

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UNIVERSITY OF BIRMINGHAM Department of Geology

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Blyth Road,
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NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, London.

READER IN APPLIED NUCLEAR PHYSICS

The Governing Body invite applications for the above appointment in the Department of Applied Physics. Applicants should possess high academic qualifications and considerable research experience in this branch of Applied Physics.

Salary Scale: £1836 rising to £2148 p.a.

Further particulars and a form of application can be obtained from

The Secretary,
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A large chemical organisation requires chemical engineers for production and research.

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IRON AND STEEL

BISRA CHEMIST or METALLURGIST

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Applicants should have a degree or equivalent qualification in Chemistry or Metallurgy.

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The Fellowship, tenable in the Department of Chemistry, is an annual appointment, renewable up to a normal maximum of three years. The salary will be in the range £800-£900 per annum, and may carry family allowance and F.S.S.U. benefits.

Applications (three copies) should be submitted to the Registrar, the University, Edgbaston, Birmingham, 15, not later than 31st December, 1960.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF PHYSICS

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THE UNIVERSITY of MANCHESTER

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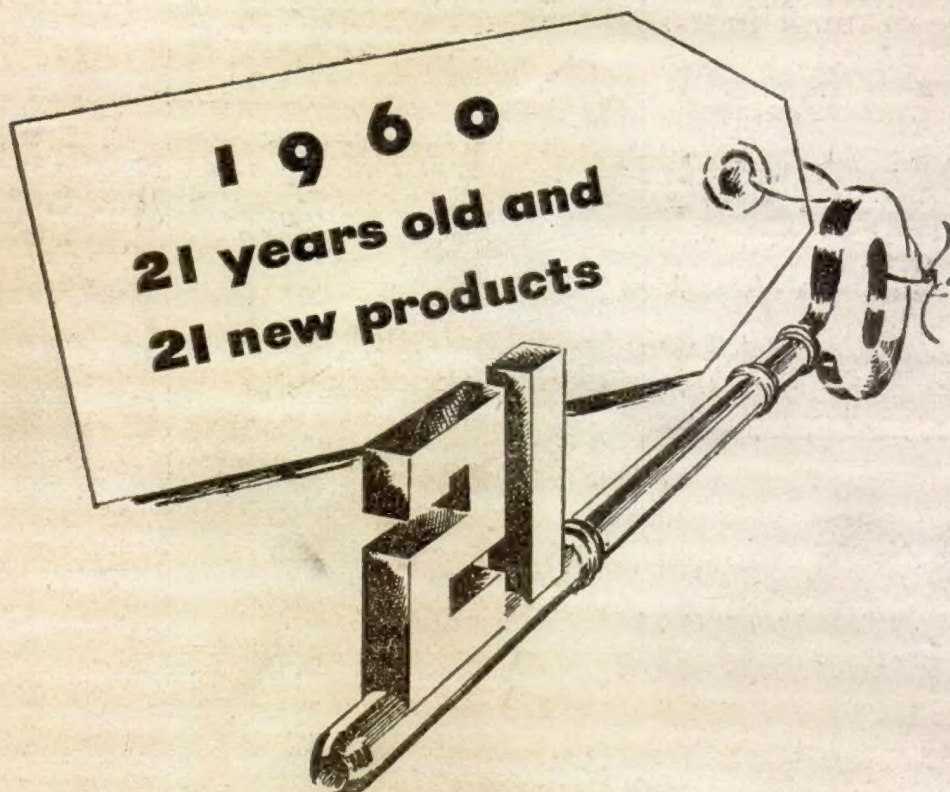
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